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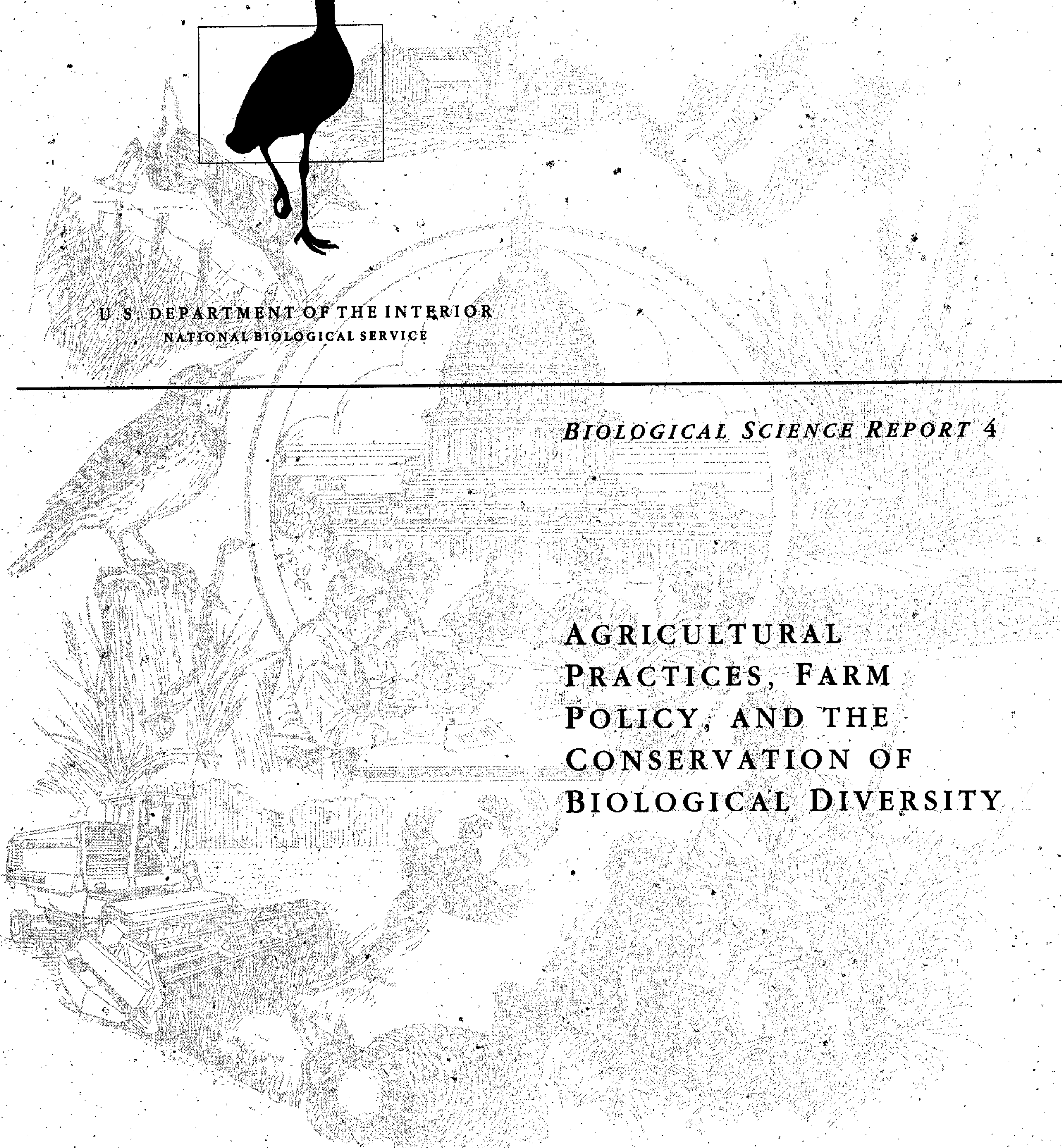

AGRICULTURAL PRACTICES, FARM POLICY, AND THE CONSERVATION OF BIOLOGICAL DIVERSITY

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BIOLOGICAL SCIENCE REPORT 4
JUNE 1995

AGRICULTURAL PRACTICES, FARM POLICY, AND THE CONSERVATION OF BIOLOGICAL DIVERSITY

By

Philip W. Gerard

Contents

Agricultural Practices, Farm Policy, and the Conservation of Biological Diversity

by

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Abstract. Long-term wildlife population declines are associated with changing agricultural practices. Cropland expansion, agricultural intensification, and national farm policies are all implicated in these declines. Social, economic, technological, and political factors determine where, what, and how a farmer produces crops and therefore his or her effect on wildlife habitat. Farmers are also influenced by Department of Agriculture programs, which therefore are indirectly implicated in wildlife population declines. Changes in the prairie and Great Plains agricultural landscape since the 1950's provide a clear example of the relation between federal agriculture policy, farmers' land-use practices, and the decline of grassland bird species. Early research indicates that the Conservation Reserve Program may help to slow or reverse wildlife losses, including those of several species listed as endangered. However, Conservation Reserve Program benefits to wildlife populations may vary considerably across the United States. Wildlife conservation in the agricultural landscape is limited by conflicting conservation objectives, the voluntary nature of federal agriculture programs, and the habitat requirements of many endangered vertebrate species. Biological conservation should be an explicit objective of agricultural conservation policy. The full potential of wildlife conservation within the context of farm conservation policy will require extensive collaboration between U.S. Fish and Wildlife Service and U.S. Department of Agriculture personnel and will only be realized if conservation policies are uncoupled from policies attempting to control agricultural commodities.

Key words: wildlife conservation, agricultural landscape, biological diversity, agricultural intensification, farm policy, Conservation Reserve Program, grassland bird species, endangered species.

Technical ability and capital investment in agriculture, along with human population pressure, have resulted in 4.9 billion hectares of the earth being managed for agriculture. This figure represents 36% of the 13.4 billion hectares representing the land area (including lakes and rivers) of all the world's nations (Food and Agriculture Organization 1993). Because agriculture involves such large areas, with increasingly intensive management affecting not only local species but also those distant from the crop or grazing lands, it is one of the most significant human activities affecting the conservation of biological diversity (Gall and Orians 1992).

Long-term declines in wildlife populations are associated with changing agricultural land-use practices and related habitat loss (Paoletti et al. 1992). Many species of soil-dwelling and terrestrial arthropods are declining due to modern farming activities (Pimental et al. 1992; Tucker 1992). Ring-necked pheasant (*Phasianus colchicus*), northern bobwhite (*Colinus virginianus*), and cottontails (*Sylvilagus* spp.) showed a decrease in population size of 33% to 96% in the midwestern states (depending on the state and species) from the late 1950's to the late 1970's due predominantly to changes in farming practices (Farris and Cole 1981; Mankin 1993). Changes in farming practices are implicated in the drastic declines in U.S. continental duck populations (Chandler 1989; Johnsgard 1994) and in 23 species of grassland birds (Knopf 1994). Populations of grassland bird species such as the Savannah sparrow (*Passerculus sandwichensis*), bobolink (*Dolichonyx oryzivorus*),

[1] Adapted from a 1994 graduate thesis for the Department of Biology and the Urban and Environmental Policy Program, Tufts University, 96 Talbot Avenue, Medford, Mass. 02155.

dickcissel (*Spiza americana*), and grasshopper sparrow (*Ammodramus savannarum*) declined by more than 95% in Illinois from 1957 to 1983 (Graber and Graber 1983).

Many factors affect the dynamic mixture and number of species characterizing a natural community. The intent of this paper is to examine the relations among four of these factors at work in the agricultural landscape: cropland expansion, agricultural intensification, wildlife conservation interests and issues, and national farm policies. The paper focuses on the interplay between these factors in the prairie and Great Plains regions of the United States.

Concern over the loss of endangered species is common enough to be the topic of cereal box cartoons. It is not common, however, for the public to connect what is *in* the cereal box to habitat degradation and potential threats to the viability of wildlife species or populations. I hope that describing the links between agricultural policy and production and the loss of species abundance and diversity will help people make that connection.

Biological Conservation

Diversity and abundance of all living things are determined by a network of interactions among and between organisms and their physical environment. The distribution and abundance of *Homo sapiens* have increased dramatically since the development of agriculture, some 10,000 years ago. We are many, geographically widespread, and very clever with tools. These characteristics magnify our effects on the physical environment and the impacts of our interactions with other species.

In parts of Europe the impacts of human population growth on indigenous species were moderated for a time by the establishment of vast royal or noble forests, closed to common people (Harrington 1991). However, royal forests did not exist on the North American continent when settlers first arrived. Perhaps overwhelmed by their access to the remarkable abundance and diversity of wildlife, early European settlers organized little in the way of wildlife conservation. As a result of habitat changes and heavy hunting pressures, many game species declined rapidly. As early as 1694, Massachusetts instituted a closed hunting season for white-tailed deer (*Odocoileus virginianus*) and, as the deer population continued to decline, a total ban on deer hunting from 1718 to 1720 (Cronon 1983). During the nineteenth century, many other states tried, mostly in vain, to control hunting to halt the decline of game species populations. The Bureau of Biological Survey (which later became the United States Fish and Wildlife Service) was established by the government in 1885 because of increasing concern over the extreme decline in the populations of wild game species (Harrington 1991). Federal and state wildlife conservation, which began in earnest early in this century, was predominantly the conservation and enhancement of fish and game species. Not until the 1960's did concern for nongame species become strong enough to lead Congress to pass laws for the protection of any imperiled species. These laws were followed by the Endangered Species Act (ESA) of 1973, considered the strongest and most comprehensive biological conservation law ever enacted (Thomas 1990). The ESA is currently (1994) up for reauthorization by Congress, and many legislators question the importance of species conservation. Is it worthwhile conserving threatened species?

The Problem of Species Loss

If there are over 10 million species, as suggested by entomologist David Pimental (Pimental et al. 1992), does the loss of some of this diversity represent a problem? Why do humans need Furbish louseworts (*Pedicularis furbishiaei*) or snail darters (*Percina tanasi*) or bluebirds (*Sialia* spp.) anyway? Certain organisms, such as nitrogen-fixing bacteria, organisms that release oxygen, and the plants and animals humans use for food, are clearly essential to survival. It is more difficult to value other organisms whose ecological roles are understood poorly or not at all. The multidimensional values of biological diversity are outside the scope of this report. However, these values are broadly outlined by the first few lines of the United Nations Convention on Biological Diversity (Bureau of National Affairs 1992), which refers to the

> "... intrinsic value of biological diversity and of the ecological, genetic, social, economic, scientific, educational, cultural, recreational and aesthetic values of biological diversity,...(and) the importance of biological diversity for evolution and for maintaining life sustaining systems of the biosphere...."

A common justification for preserving obscure or apparently insignificant species is that their extinction may lead to other species' extinctions (Ehrlich and Ehrlich 1981). Experience with species loss and research in ecology indicates that this is not always the case. Redundancy does exist in natural systems, and not all species are so inextricably linked that removing one will cause the whole ecosystem to crash. But precisely because many species *are* inextricably linked, there are many cases where the conservation of one species automatically results in the conservation of others. The opposite occurs as well; the decline or extinction of one species may lead to the decline or extinction of others (Ehrenfeld 1992). In only a small fraction of plant and animal communities has this interrelationship between species been studied in detail. Therefore, when we disturb a natural system we may not be able to accurately predict the consequences of our actions (Pimm 1991).

Recent Increases in Loss of Biological Diversity

Low rates of species loss are a natural part of evolution. However, as a result of our human range, population, and technology, this extinction rate has been vastly accelerated (Wilson 1992). Declines in species diversity and abundance associated with the conversion of natural areas into towns, cities, and farms have become apparent. Since the 1500's, at least 106 vertebrate species have become extinct in the United States, U.S. territories, and Canada; 71 of these 106 species became extinct during the twentieth century (Williams and Nowak 1986).

Reduction in abundance within and among discrete populations of a species leads to the loss of biological diversity, as significant to local communities, although not as final, as extinction. Fluctuation in abundance is common in the demographic cycles of many populations. However, when humans reduce populations directly through harvesting or hunting, or indirectly through disturbance, major fluctuations may threaten species survival. The same natural factors that cause fluctuation may still exist, but with a smaller population the fluctuation may reduce the population to below its minimum viable size, which leads directly to extinction (Noss and Cooperrider 1994). Table 1 outlines groups of animals endangered as a result of low population size.

Biological Conservation Issues

Simply defined, biological conservation means maintaining the viability of living things. There are many forms of biological conservation and at least as many complicated issues related to its management. Some of these issues encompass conflicts that have a direct bearing on biological conservation within the agricultural landscape.

Historically, most conservation efforts have been directed toward conserving a limited number of species considered valuable for food or fur. The primary consideration was the abundance of species good to eat or wear (Thomas 1990). Over the past few decades the conservation interests of the American public have expanded to include non-consumptive recreational uses, concern over endangered species, and an interest in biological diversity (Harrington 1991). These new interests may result in conflicting conservation objectives. For example, conservation managers may need to make decisions about existing versus pre-existing wildlife, game versus nongame species, and biological diversity versus endangered species.

Existing Versus Pre-existing Wildlife

Which natural community is desired, that of the historically undisturbed landscape or that of the human-transformed landscape? Conservation efforts to renew pre-European species diversity may reduce the abundance of popular introduced species. Occasionally, ironic twists occur. For example, near Santa Cruz, California, a grove of Eucalyptus trees (*Eucalyptus* spp., a weedy exotic from Australia) provides an important roosting site for overwintering monarch butterflies (*Danaus plexipus*). In Britain, hedgerow plantings, an entirely human construct, provide the only habitat for certain British species (Macdonald and Smith 1990).

Table 1. Selected animal groups with alarming rates of population decline, early 1990's (from Ryan 1992).

Animal group	Status
Amphibians[a]	Worldwide decline observed in recent years. Drainage of wetlands and invading species have extinguished nearly half New Zealand's unique frog fauna.
Birds	Three-fourths of the world's bird species are declining in population or threatened with extinction.[b]
Fish	One-third of North America's freshwater fish are rare[c], threatened, or endangered; one-third of U.S. coastal fish have declined in population since 1975. Introduction of the Nile perch (*Lates niloticus*) has helped drive half of the 400 species of Lake Victoria, Africa's largest lake, to or near extinction.
Invertebrates	On the order of 100 species are lost to deforestation each day. Germany reports one-fourth of its 40,000 known invertebrates to be threatened. Roughly half the freshwater snails of the southeastern United States are extinct or nearly so.
Mammals	Almost half of Australia's surviving mammals are threatened with extinction. France, Germany, the Netherlands, and Portugal all report more than 40% of their mammals as threatened. All cetaceans (whales and dolphins) are treated by the Convention on International Trade in Endangered Species as threatened or likely to become so.
Carnivores	Virtually all species of wild cats and most bears are declining seriously in numbers.
Primates[d]	116 of the world's roughly 200 species are threatened with extinction.
Reptiles	Of the world's 270 turtles species, 42% are rare or threatened with extinction.

[a] Class that includes frogs, toads, and salamanders.

[b] Definitions of "threatened" and "endangered" vary, but generally "endangered" means in imminent danger of extinction, and "threatened" includes species imperiled to a lesser degree.

[c] Many species are naturally rare; others have been made rare due to human activities. Rare species are vulnerable to endangerment in either case.

[d] Order that includes monkeys, lemurs, and humans.

Game Versus Nongame Species

An objective to manage for the maximum number of game animals per square kilometer may or may not increase diversity. For example, opening up edge habitat for white-tailed deer may threaten nongame forest interior species. Woody habitat development for avian game species may result in increased nest predation or brood parasitism on nongame species (Allen 1993b; Warner 1994).

Biological Diversity Versus Endangered Species

The abundance of some species may be a principal factor in the decline of others. Managers may consider exterminating the abundant species if they are common elsewhere and the declining population is endangered. Part of the biological diversity of an area may be the result of alien or exotic species introductions. These species may slowly degrade the habitat of the indigenous species. To conserve the endangered species, the diversity of the area may need to be reduced. In these cases conservation objectives may be very difficult to establish.

Resolving these conflicts, case by case, although challenging, is essential. Human impact on natural systems is so pervasive that our best efforts to conserve wildlife abundance and diversity are required. The rate of species extinctions has accelerated over the last 200 years as a result of many interconnected factors. One of the factors, agriculture, has had particularly widespread and dramatic effects on indigenous plant and animal populations.

Agricultural, Ecological, and Human Dynamics

Since its beginnings, some 10,000 years ago, agriculture has steadily transformed natural areas into croplands, orchards, pasture, and range. Self-organizing, complex natural communities are converted into managed, often highly simplified, communities of plants, animals, and other organisms. Replacing nature's diversity with a smaller number of plants and animals allows for the capture of more photosynthetic energy and nutrients for human use. The resulting increase in human food produced per unit area is the foundation for the development of our urban societies.

Until relatively recently, biologists have not considered agricultural alterations to landscapes a major force in the loss of biological diversity. Perhaps general optimism related to increasing yields through scientific management, or the feeling that plentiful wild "frontiers" still existed on our planet, kept conservationists from focusing on agriculture as a key problem (Gall and Orians 1992). Popular concerns about agriculture and biological conservation probably did not arise until publication of Rachel Carson's *Silent Spring* (1962), which resulted in increased scientific attention to the effect of agricultural chemicals on non-target species. Although popular concern over agricultural practices and their threat to biological diversity may be recent, the agricultural degradation of soil and water resources is not a modern problem. Some 3,000 years ago, the city of Ephesus, a major trading center supporting a large population in western Asia Minor, lost its port and was eventually abandoned as a result of agriculturally related soil erosion. Perhaps Ephesus also experienced wildlife population declines or extinctions. However, the relatively small population and limited technology of humans made agriculture's effect on natural systems less widespread and intense than at present, when nearly 40% of the earth's land area is managed for agriculture (Food and Agriculture Organization 1993).

Agriculture and the Disturbance of Natural Systems

The nature and intent of modern agriculture is to reduce biological diversity. We replace the natural diversity of an area with a limited number of species that are useful to us, creating a highly simplified agro-ecosystem. However, the reduction of diversity varies from one agricultural system to the next, indicating that there may be some choice in the degree of natural system disturbance created by agriculture.

Agriculture is as diverse as the food and fibre crops it produces and the areas in which it is practiced. Agriculture as a whole (leaving out fishing, but including forestry and grazing on natural grasslands) can be divided into three categories—no input, low input, and high input—on the basis of the degree of community simplification, intensity or expense of human inputs and manipulation, management complexity, and self-regulatory ability (Gilpin et al. 1992). Figure 1 illustrates these categories, which are meant to delimit a continuum of the ecological dynamics of agricultural production.

No Input Agriculture

No input agriculture describes what are essentially harvest-only systems. Examples include rangelands dominated by domestic animals, and the gathering of wild greens or rice (*Oryza sativa*). These types of agricultural systems tend to be very complex from an ecological perspective and relatively simple from a management perspective. Management is simple in the sense that manipulation tends to be limited to controlling the amount of crop or livestock units harvested. Managers hope that these systems may be exploited indefinitely if care is taken to avoid overuse. These systems are expected to be relatively self regulatory in relation to fertility, disease, and pest control (not necessarily extended to livestock parasite control). The community

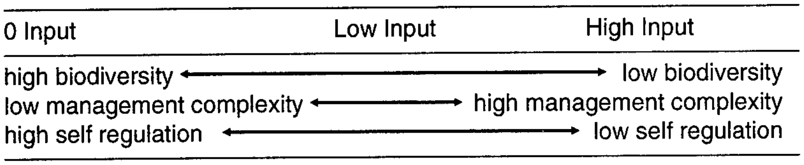

Fig. 1. Ecological dynamics of agricultural production. As inputs (time, fuel, fertility, pest control) increase, management tends to become more complex, while the biological diversity and self-regulatory ability of the area are reduced.

structure, although often fundamentally disturbed, retains a relatively large percentage of its original biological complexity compared with the following two systems.

Low Input Agriculture

Low input agriculture involves the planting of desired species or the active removal of competing organisms, but at a small scale and with few inputs other than seed and human labor. Examples include range management that involves removing unwanted species or fencing, and certain indigenous or peasant farming systems (Altieri 1990). These systems are less ecologically complex than no input systems and are relatively more management intensive as a result of the increase in options for system manipulation.

High Input Agriculture

High input agriculture involves production of plants and animals that are dependent on human management and that require relatively costly inputs of energy and chemicals. This type of agriculture often completely supplants existing natural systems. High input agriculture, therefore, is likely to be the least complex farming system ecologically and the most complex from a management perspective because of the number of practical management options: tillage treatments, pest control tactics, nutrient supplementation, timing of activities, harvest methods, and so on. These systems are considered to have few or no self-regulatory functions related to disease and pest control or fertility. Much of U.S. agriculture fits into this category.

The degree of ecological simplification in high input agriculture can be remarkable. An asparagus (*Asparagus officinalis*) field in California may have been prepared for planting by leveling with a laser-guided grader to reduce the opportunity for fungus to develop in low spots and to increase irrigation efficiency. The soil may have been fumigated with methyl bromide or other agents, resulting in the extirpation of many of the soil species that survived tillage. Thereafter, the crop is regularly supplied with nutrients, including water, and sprayed with insecticides and herbicides. Perhaps only by paving the field would it be possible to further reduce species diversity.

Of the various ways in which we manage terrestrial ecosystems, row-crop agriculture has the largest impact in terms of area and disturbance (Pimental et al. 1992). If a forest or grassland is completely cleared and plowed, then most, if not all, of the ecosystem functions carried out by the native community will be lost or dramatically altered. Species dependent on those functions will simply die or disperse to other less disturbed areas.

Habitat Fragmentation, Community Structure, and Farmland Wildlife

According to the U.S. Fish and Wildlife Service (1980, p3.2B [2]), each species "requires a particular habitat to supply the space food, cover, and other requirements for survival. Thus, species are the products of their habitats." The variability in numbers of species and individuals within species populations results from the structural characteristics of the habitat itself, as well as from differences in the availability of nutrients, cover, and other requirements. Agriculturally related biological diversity loss is primarily the result of habitat destruction.

Habitat fragmentation, resulting from the piecemeal destruction of habitat characteristic of agricultural development, initiates a process that can eventually have major consequences for wildlife. Increased fragmentation results in a decrease in total habitat and average size of habitat patches, an increase in patch isolation, and an increase in the ratio of edge to interior habitat. Less habitat usually results in less wildlife. The reduction of habitat patch size may also result in habitat too small to meet the minimal territory requirements for a species or lacking essential resources necessary for the viability of a population (Diamond 1975). Nearly all bird species exhibit a minimal area threshold below which they will not occur. Herkert (1991), working in Illinois, reported that 6 of 17 grassland bird species were never encountered on areas of less than 10 ha, and two of those six species were not encountered until grassland plots were greater than 30 ha. Because small habitat patches support fewer individuals, the influence of stochastic events on population demography may be increased. Fluctuations in abundance are a fairly common characteristic of natural populations. However, in a large habitat area, with a population of 50, the loss of three individuals is less significant to that population's persistence than the loss of three individuals from a fragment of habitat with a population of five. Therefore, habitat fragmentation may lead to an increased probability of local population extinction (Herkert 1991). Two important influences on avifaunal community composition should be

acknowledged when considering the effects of agriculture on grassland bird habitat. The first is that the size of the block of relatively uniform habitat type is significant. Wiens and Dyer (1975) reported that habitat plots of less than 12 ha supported only a single species of grassland bird. Only a 32.4-ha habitat block that was surrounded by fallow land and pasture supported the full complement of typical tallgrass prairie bird species. The second influence is distance between habitats. Most grassland birds species are wide-ranging, perhaps an adaptation to the unpredictability of the Great Plains habitats. However, there may be limits to how successfully these species will disperse across broad areas of unsuitable habitat (Wiens and Dyer 1975).

The extent and form of agriculture practiced governs the degree of disturbance and change to community structure. Some species present at the time of conversion to agriculture will survive in the area (with their abundance dependent on the quality of habitat created by the conversion). Other species present will be unable to survive these changes and will either move to more appropriate habitat, slowly decline in abundance, or die out rapidly. Concurrently, alien, opportunistic species may move into the area, and exotic species may be introduced. In the Great Plains perhaps 37 species of birds were endemic or secondarily evolved to grasslands (Mengel 1970; Wiens and Dyer 1975; Knopf 1995). As a result of the transformation of this region, in particular the introduction of woody plants, 330 out of the 435 bird species breeding in the United States now breed in this area (Johnsgard 1979). However, the populations of 23 of the 37 "original" bird species have declined steadily over the past 3 decades (Knopf 1995). Several grassland bird species actually benefited initially from the early stages of prairie-to-farmland conversion. In Illinois, the horned lark (*Eremophila alpestris)*, vesper sparrow (*Pooecetes gramineus)*, and greater prairie-chicken (*Tympanuchus cupido)* particularly benefited, either as a result of their ability to colonize and breed in cultivated habitats or from the new intermixed pattern of food and cover. Fur trapping and hunting may also have reduced risk from predatory animals (Herkert 1991). However, continued changes in agriculture now threaten these same species.

Species that live in the agricultural landscape are often described as habitat generalists, that is, species adapted to use a broad range of habitats. Habitat specialists are species that require more specific habitat characteristics. Given the patchy nature of many agricultural landscapes, the characterization of all agricultural species as habitat generalists is probably an oversimplification. However, most wildlife species affiliated with agricultural landscapes can be categorized into two groups. Species that may do well in the agricultural landscape, if their basic habitat requirements are met, would fall into one group. Examples of this group include white-tailed deer, ring-necked pheasant, raccoon (*Procyon lotor*), mourning dove (*Zenaida macroura*), and northern bobwhite. In general, as the area of cropland increases within a region, with attendant decreases in interstitial and semi-natural areas, the diversity and abundance of this group of species will decline (Macdonald and Smith 1990). The second group includes those species indigenous to either grassland or forest habitat whose populations are often harmed by either habitat fragmentation or isolation within landscapes predominantly involved in silvicultural or agricultural production (Allen 1993b). Examples of this second group include the red-cockaded woodpecker (*Dendrocopos borealis*), which cannot survive in fragmented long-leaf yellow pine habitat surrounded by farmland, and the upland sandpiper (*Bartramia longicauda*), which requires large areas of relatively undisturbed grassland as habitat.

Throughout this paper I will use the term farm wildlife to refer to the vertebrates adapted to survive within the disturbance landscapes created by agriculture. Although many classes of terrestrial organisms are represented in the agricultural landscape, most of my examples are avian, as much of the related research in the United States has focused on birds.

Agricultural Production Practices

Where and what a farmer produces and how that production is managed influence the degree of ecosystem disturbance, changes in community structure, and resulting loss in species diversity or abundance. Although some species adapt to survive within an agricultural context, changes in agricultural production practices within that context can threaten their survival. Within a production system for any particular crop, specific management practices can affect biological diversity (Paoletti et al. 1992). One farmer's methods of rice production may conserve insect and bird diversity; another rice farmer's practices may threaten or kill bird, insect, and fish populations. Principal categories of agricultural practices affecting nonagricultural species include the following: habitat alterations such as drainage, field enlargement, or reduction in crop interspersion; agricultural intensification characterized by reduced crop heterogeneity, increased irrigation, increased or more aggressive tillage, and the cultivation of marginal lands; livestock management related to stocking densities and timing of forage harvests; and pesticide use leading to wildlife mortality, reduction in reproductive success, and the loss of wildlife food and cover (O'Connor and Boone 1992; Tucker 1992). The management of field margins, "waste areas," and soil conservation structures can also have important consequences for agricultural wildlife (Farris and Cole 1981; Macdonald and Smith 1990; Thomas et al. 1992).

Annually, several hundred million kilograms of pesticides are spread over U.S. farmlands, livestock, and buildings (National Research Council 1989; Robinson 1991). Many pesticides contain toxins that may affect the survival of wildlife species, not only where the toxins are applied but also downstream and downwind. These toxins poison large numbers of non-target organisms. One insecticide, Carbofuran (now limited by the Environmental Protection Agency), was blamed for 1 to 2 million bird deaths in the United States annually (Hoffman et al. 1990). Although considerable mortality and reduction of viability is attributed to these substances, many biologists feel that the indirect effects of pesticides may be even more damaging than the direct toxic effects (Palmer and Bromley 1992). Indirect effects include loss of prey and habitat and subsequent negative consequences to the stability of community structure. Recent research has implicated long-lasting residues of organochlorine pesticides (many currently restricted or banned) in reduced reproductive success of several wildlife populations (Colburn 1992).

Where and what a farmer produces and how that production is managed affects biological diversity and abundance. What influences farmers' choices in these matters? There are several important factors within the economic, social, political, and environmental context of agriculture that control, to a large extent, where and how farmers farm.

Social, Economic, and Political Context of Agriculture

Beyond policies implemented by governments that regulate their use, natural ecosystems are not dependent on human intervention. In contrast, high input agricultural ecosystems are completely dependent on, and interconnected with, their human managers' social, economic, and political environments. Market forces, food choice, urbanization, economic development, agricultural technology, and public policy affect how and where farmers farm and therefore their impact on wildlife communities.

Agricultural Markets

Markets are a central force influencing the land-use practices of farmers. A dramatic example of the influence of agricultural markets occurred in the 1970's when demand for feed grains in Europe, Eastern Europe, the Soviet Union, and some less-developed countries led to a 28-million-ha expansion in cultivated crop land in the United States (Paarlburg 1980; Cook 1985). Many decisions a farmer makes about what should be produced, the scale and financing of the operation, and the crop or livestock management practices are based on the farmer's perception of market forces (Castle et al. 1972). Market forces interact with and are modified by many factors, including those listed in this section.

Food Choice

Cultures identify strongly with certain foods, even when production of these foods may be a poor survival choice or lead to environmental degradation. For example, in southern and eastern Africa, porridge made from corn (*Zea mays*) (introduced into East Africa in the late 1800's) has replaced other indigenous staple porridges from South Africa to Uganda. In some areas where rainfall is regularly inadequate farmers will risk growing corn rather than the more dependable indigenous sorghum (*Sorghum vulgare*) because corn is so highly favored (Samual Mahlala, Kingdom of Lesotho Agricultural Extension Service, personal communication). Popularization of a health culture in the United States is a significant factor in declining consumption of red meat, eggs, and other foods once considered the mainstay of the American diet (U.S. Department of Agriculture 1991c).

Agricultural Technology

The availability and cost of agricultural mechanization, synthetic inputs, and genetic advances in seed and livestock exert a powerful influence on the land-use practices of farmers (Doering 1992). For example, until tractors became inexpensive and practical, farmers needed to maintain large areas of their land in pasture, hay, and grain crops to fuel their draft animals. Synthetic fertilizers and pesticides allow farmers to decrease their dependence on livestock wastes and crop rotation for the maintenance of soil fertility and crop yields.

Urbanization and Economic Development

Our modern capitalist industrial economy grew out of agriculture.[2] Production beyond subsistence formed the basis for economic development. The more that people leave the land to work in urban centers, the more demand there is in the urban markets for agricultural goods. The development of urban areas and public works is impossible without a plentiful and relatively inexpensive source of food. The growth of cities and industry also provides expanded employment options, which may reduce the agricultural workforce and increase the available agricultural resource base for farmers who remain on the land. Historically, the availability and price of agricultural goods have been linked with economic growth and political stability, which has made agricultural policy a vital component of government in industrialized countries.

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[2] The word capital (in capitalist) derives from capita or head, referring to the early Phoenician coins that were decorated with the head of a bull (Fuller 1981). Money was simply a more portable symbol for livestock which was the real or eventual payment. The expression "payment in kind" derives from the Old English root for cattle: kine. Another cognate for cattle is chattel (or property).

Policy

The term agricultural policy may actually be somewhat misleading in that it implies a single or coherent group of programs or regulations. Agricultural policy involves many different programs, each developed to address diverse problems or aspects of problems. In the United States, agricultural policies address agricultural commodity price and income support, export promotion, farm financing, domestic and international nutrition, agricultural taxation and credit, research, extension and education, trade and domestic economy, soil and water conservation, and related environmental issues. (National Research Council 1989; Allen 1990).

The demand and supply signals of agricultural markets constrain the impact of agricultural policies on farmers' behavior. However, most developed countries choose to manipulate agricultural markets to ensure a stable, inexpensive supply of food and higher incomes for farmers (Doering 1992).

Agricultural policies are not only oriented towards a steady, cheap supply of food but also often integrated into a broader economic or geo-political strategy. For example, until recently, as part of a national security policy, Japan maintained self sufficiency in rice production, at extreme cost to the taxpayers. During the Nixon administration the U.S. Government saw an opportunity to support détente in the export of grain to the Soviet Union (Paarlberg 1980). Government policy influences the direction of agriculture through a variety of economic, regulatory, and agricultural development programs and policies.

Policies Affecting Agricultural Landscape Species

Although market forces are important, what farmers grow, and where and how they grow it, is clearly influenced by public or government policy. This influence changes in relation to agricultural markets and other factors. However, some years these programs have substantial effects, as in 1987, when farmers operating 60% of harvested U.S. cropland were strongly influenced by farm commodity program rules and incentives (National Research Council 1989; U.S. Department of Agriculture 1991b). In the late 1970's (coincident with increased international demand) farm policies that encouraged exports, subsidized inputs, and stimulated production led to more intensive production, over a larger area, than would otherwise have occurred (Doering 1992).

Arguably, without the agricultural policies of the past, the situation for wildlife could now be far worse. A completely unregulated market may have resulted in even larger areas under tillage or even more dramatic fluctuations in cropland area. However,the connections between agricultural policies, agricultural production, and the quantity and quality of wildlife habitat make it very clear that agricultural policies must be considered in the overall context of wildlife conservation.

Past federal agricultural policies that supported the development of major cropland areas, such as irrigation projects in California and drainage projects in southern Florida, had large-scale, deleterious impacts on wildlife habitat. Other agricultural policies developed during and after the 1930's had less obvious but nonetheless significant wildlife impacts. These policies, reviewed below, were related to commodity price support, tax policy, agricultural research and extension, and farm conservation programs.

National Commodity Support and Adjustment Programs

Developed to adjust supplies, support prices, encourage exports, and maintain income for farmers growing certain agricultural commodities, these programs have helped boost farm income. These programs also have helped promote the conversion of heterogeneous, habitat-rich agricultural landscapes into homogeneous, habitat-poor landscapes (Berner 1988), while discouraging sustainable farming practices that may benefit biological diversity, such as crop rotations, cover crops, reduction in agricultural chemical use, and farm diversification, including livestock (Robinson 1991). Agricultural legislation in 1985 and 1990 (which will be described later in this report) attempted to reform related policies to avoid some of these side effects.

Tax Policy

National tax policies can influence farming practices, which in turn can affect biological diversity. For example, before the passage of the Tax Reform Act of 1986, agriculture received special consideration on investment credit, depreciation, and capital gains treatment. Farmers or investors in agriculture were allowed to exclude 60% of income received from the sale of assets such as land and breeder stock. Tax shelters through investment tax credit and particularly capital gains treatment provided incentives to purchase inexpensive wetlands, rangelands, or forestlands, convert these lands to cropland, sell them at a profit, and exclude 60% from taxation (Grieves 1983; Watts et al. 1983; Heimlich 1986; National Research Council 1989).

Research and Education Policy

Governments often support agricultural research and education. Historically, emphasis has often been on enhancing marketable yields to the exclusion of many other potential goals, such as maintaining environmental quality or rural culture. Since the 1940's, the focus has been on

synthetic-input-based technologies that increased yields and simplified farm management (Dahlberg 1992). Many practices that grew out of this research may threaten biological diversity, such as the increase in the exclusive use of pesticides for weed, insect, and disease management and the use of technologies that require large field size to be cost-effective (Robinson 1991).

Conservation Programs

Paradoxically, agricultural conservation policy has not always helped to conserve agricultural resources, let alone wildlife. Regulations on land taken out of production, ostensibly for conservation purposes, often created poor or even dangerous habitats (habitats that initially provide appropriate food or cover but may later increase mortality due to predation or farm operations such as mowing, spraying, or tillage), particularly for birds (Berner 1988). Other policy provided funding for field expansion (in connection with drainage or soil conservation work) through the removal of walls and fence rows. This process usually involved converting a mosaic of fields, swales, and brush or wooded areas into one or more large uninterrupted fields, allowing efficient cultivation with modern, large farm equipment. Large-scale mechanization of agriculture is thought to increase yields, weed out marginal producers, and ensure a large, low-cost supply of food. In the United States this mechanization may have helped wipe out floral and faunal diversity that coexisted within a more heterogeneous agricultural landscape. (National Academy of Sciences 1970).

Human, agricultural, and ecological dynamics interact to transform the landscape. The resulting landscape can be as varied as the human societies and natural substrates that create them. The next section of this report reviews a transformation that occurred at an unprecedented rate, the agricultural development of the northern temperate grasslands of the United States.

Agricultural Transformation of the American Grasslands

Historically, the Great Plains and prairie states were part of a grassland biome called the northern temperate grassland (Shelford 1963), comprising 1.5 million km^2 and covering a region from south-central Saskatchewan to central Texas, and from the Palouse region of eastern Washington and Oregon to Illinois. The tall-grass prairie, on the eastern side of these grasslands, was made up of communities of grasses and forbs growing a meter or more in height. Western grassland communities, or short-grass prairies, were half this height and less dense. Streams in these areas were predominantly open or sparsely wooded (Knopf 1995).

Native Americans did modify significant areas of the landscape as a result of agricultural practices, hunting, or wildlife management (Cronon 1983). However, wholesale transformation of these grasslands did not occur until the nineteenth and twentieth centuries and was a product of the activities of more recent immigrants. As described by Knopf (1995), European settlers significantly altered the native wildlife habitat of these grasslands as a result of four activities discussed below: plowing of native grasslands for crop production, extermination of native grazing animals and introduction of cattle and sheep, draining of wetlands, and woody plant introductions.

The eastern grasslands (Illinois and Iowa) were nearly completely converted to croplands. For example, in Illinois only about 10 km^2 out of an estimated 103,600 km^2 of tall grass prairie remain (Knopf 1995). Farms in the central and northern Great Plains states (Kansas, Nebraska, Oklahoma North Dakota, South Dakota) have retained an average of 59% of native grasslands. An average of 72% of the grasslands in the western Great Plains states (Colorado, Montana, Wyoming) have remained unplowed (Knopf 1995). Plowing of native grasslands was not only an early twentieth century labor. The expansion in cropland from 135 million ha in 1969 to 155 million ha in 1982 (U.S. Department of Agriculture 1991c) included the conversion of native grassland into cultivated areas (Grieves 1983; Heimlich 1986).

Bison (*Bison bison*) were extirpated from the grasslands by the late 1800's and were rapidly replaced by domestic herbivores. Cattle and sheep, managed appropriately, might have provided some of the same "ecosystem services" formally carried out by the bison. However, excessively large herds and the fencing of rangelands restricted the natural grazing patterns of cattle and sheep. Fencing led to a standardized grazing intensity (Knopf 1995), which alters the community structure of native grasslands (Savory 1988). Riparian zones are among the most productive and biologically diverse habitats in this area. Uncontrolled livestock grazing along stream systems alters streamside vegetation, stream channel morphology, and water and soil quality (Kauffman and Krueger 1984), and threatens or reduces the viability of many species of riparian plants and animals (Fleischner 1994).

Wetlands have been drained in this region primarily to improve or increase cultivated area. Therefore, wetland loss seems to correspond to the regional extent of cropland. In Illinois, Indiana, and Iowa more than 85% of historical wetland area has been drained (Dahl 1990). In the central and western plains 56.6% and 40%, respectively, of historic wetland area have been lost to agriculture (Knopf 1995). Before the mid-1970's nearly all wetland losses in this area were due to agricultural development (Dahl and Johnson 1991). Continental wetlands provide nesting, migratory, and wintering areas for 50% of our migratory bird species and important habitat for about one-third of the

plant and animal species listed as threatened or endangered by the Federal Government (U.S. Fish and Wildlife Service 1990). Populations of duck species that breed in these wetlands dropped 18% between 1979 and 1986 (Chandler 1988). The 1991 breeding populations of mallards (*Anas platyrhynchos*), redheads (*Aythya americana*), and northern pintails (*Anas acuta*) are 27%, 26%, and 62% below their 1955–90 long-term averages. These population declines are attributed in large part to the loss of wetland habitat in the northern Great Plains (Johnsgard 1994).

Although woody plants were found in riparian areas of the eastern tall grass prairie, little encroachment onto grasslands occurred. Fire played an important role in maintaining grassland communities and in preventing encroachment of woody plants. Control of wildfires has allowed woody vegetation to expand onto the grasslands of the Great Plains (Knopf 1995). At present, streamside forests include alien and exotic tree species as a result of twentieth century water management practices (Knopf 1995). Almost 3% of the Great Plains is now planted in tree and shrub shelterbelts to reduce wind erosion, and more than 20 million trees are planted annually (Baer 1989).

Grassland Agricultural Development and Wildlife Diversity

Bison, antelope (*Antilocapra americana*), elk (*Cervus elaphus*), bear (*Ursus* spp.), gray wolf (*Canus lupus*), badger (*Taxidea taxus*), and mountain lion (*Felis concolor*) were among the large mammals that occupied these grasslands before the arrival of European settlers. Their populations are now absent or drastically reduced as a result of agricultural conversion and hunting (Shelford 1963). A less appreciated but important mammal, the black-tailed prairie dog (*Cynomys ludovicianus*) has been extirpated from 98% of its former range, mostly by poisoning (Miller et al. 1994). Although much smaller than the bison, the spatial impact of this species on western landscapes was extraordinary. A prairie dog complex of 55,000 ha still exists in northern Chihuahua, Mexico (Ceballos et al. 1993), and anecdotes describe far larger prairie dog towns that existed in Texas (Worster 1979). These animals have been systematically eradicated because of assumed grass forage competition between the prairie dogs and cattle (Miller et al. 1994). Research indicates that this assumption is not supported by data and that prairie dogs and ungulates are actually symbiotic grazers (Krueger 1986). As a keystone species, prairie dogs are ecosystem regulators and provide habitat or prey for other species, including endangered species or those proposed for listing as endangered, such as the black-footed ferret (*Mustela nigripes*), ferruginous hawk (*Buteo regalis*), mountain plover (*Charadrius montanus*), and swift fox (*Vulpes velox*) (Miller et al. 1994).

Long-term monitoring of other small mammal populations (not trapped for fur) has not been conducted. The few studies involving quantitative assessments of population changes are based on infrequent and geographically restricted studies. Nonetheless, the extensive habitat changes that characterize the agricultural transformation of the prairies and Great Plains probably had significant, negative impacts on populations of many small mammal species (Thomas 1990). Available data show that some species of Great Plains bats are at particular risk, primarily from human disturbance but also from agriculturally induced reduction in prey populations and pesticide contamination (World Wildlife Fund 1990).

The transformation of relatively undisturbed natural areas into agricultural landscapes changed the community structure of wildlife populations across the temperate grassland biome. The abundance and diversity of indigenous species have been reduced over broad areas of this region. Continued changes to the agricultural landscape are threatening many of the remaining species.

Changes in the Agricultural Landscape Since the 1950's

Agricultural landscapes are not necessarily homogeneous or static. In their early stages of development they may constitute a matrix of cultivated and native areas. In highly developed agricultural landscapes the matrix elements of grasslands, shelterbelts, woodlands, shrub areas, and wetland may become rarer. Then cropped areas themselves may begin to play a significant role in determining the quality and quantity of habitat available to wildlife. In many areas agricultural landscape diversity has changed considerably over the past 20–40 years. In Nebraska there was a 45% decrease in land planted to potential nesting cover (hay and pasture) from 1955 to 1976. Small grains (which can provide feed and cover for some species) other than winter wheat became virtually nonexistent by 1976 as well. In Iowa during this period, land devoted to corn and soybeans (*Glycine max*) increased 44%, while land in hay and pasture declined 44% (Farris and Cole 1981). Commonly those cultivars least resembling native grasslands, such as soybeans and corn, are now planted in vast, unbroken fields, while those crops bearing the closest resemblance to natural habitats, such as pasture or mixed grass hay, occur only in small isolated patches (Wiens and Dyer 1975). Warner (1991) suggested that changes in Illinois farming practices involving an increase in row crop farming and decrease in oat-hay rotations may explain 90% of the 50% decline in the small game harvest over the past 30 years.

Reduction of agricultural landscape diversity seems to be a trend common in most areas of the country involved in growing feed grains and grain for human consumption (Barrett et al. 1990). This reduction in diversity implies an

increase in the percentage of land managed for annual row crops, a reduction in perennial covers, the loss of farmland wildlife habitat quality, and an increase in low-quality or dangerous habitat.

Factors Influencing Recent Changes in the Agricultural Environment

As mentioned earlier, a farmer's land-use decisions are influenced by many interconnected factors. An important factor over the past 25 years has been the growth of export markets for commodities such as corn, wheat (*Triticum aestivum*), and soybeans. These markets have had an enormous influence on the agricultural landscape of this region. A 20-million-ha expansion in cultivated crop land from 1969 to 1982 (U.S. Department of Agriculture 1991c) occurred concurrently with the dramatic increase of export sales. Beginning with the Russian grain sales of the early 1970's, American corn, wheat, and soybean farmers became increasingly dependent on export markets. Although exports began to weaken in the early 1980's, as a result of increased competition from other nations, the market continued to encourage farm management trends towards cash crop specialization, with a consequent expansion of the land in cultivated crops. An average of 25% of corn, 58% of wheat, and 40% of soybean production was exported between 1976 and 1989 (not including unusually low yield years that would increase these percentages; U.S. Department of Agriculture 1991c). These export markets were actively developed by the Department of Agriculutre (USDA), and farmers were encouraged to increase production for these markets (MacFadyen 1984). Substantial areas of grasslands were plowed under during this period (Grieves 1983), and although only about half of wetlands drained after the mid 1970's were used for agriculture (Dahl and Johnson 1991), these changes constituted a significant loss of habitat for species dependent on wetlands and grasslands for breeding, feeding, or cover.

Another important factor, technology, has been influential in this recent transformation of the agricultural landscape. Refinements in agricultural technologies over the past 3 decades have allowed farmers to successfully manage very large areas without the need for crop rotations involving perennial grasses or legumes (which increase and enhance wildlife habitat). A survey by Gill and Daberkow (1991) revealed that the two most common cropping sequences in 1990 (in the 10 major corn-producing states) were continuous corn and corn-soybean-corn.

The landscapes of cropland regions of the prairie and Great Plains have been shaped by many factors, some related to the culture connected with rural communities some to the individualism of farmers. Markets, along with financing, machinery, fertilizer, and other input costs, also affect farmers' decisions. Management ability or experience may dictate a farmer's cropping plans. Although the extent of influence of agricultural policies on farming practices is debatable (Doering 1992), farm programs obviously have had an important effect on agricultural land use in the United States (Paarlberg 1980; Sampson 1981; National Research Council 1989). From 1982 to 1990 an average of 56% of lands planted to major crops were affected by federal farm program regulations (Economic Research Service 1991). Because farm programs may be more malleable than other factors influencing agriculture, it is important to understand how these programs affect the biological landscape of rural areas. The next section of this report reviews the history of U.S. agricultural programs and describes their effects on habitat and wildlife.

United States Agricultural Commodity and Farm Programs

The objective of federal commodity[3] programs is to support and stabilize crop prices and farmers' incomes. This is accomplished through agricultural programs that support commodity prices, retire land, make direct payments to farmers, and encourage or subsidize exports. These programs are a significant force in U.S. agriculture. From 1984 to 1993 18% to 42% of net farm income (an average of 28.5%) came from direct government payments (U.S. Department of Agriculture 1991d; update from U.S. Department of Agriculture personal communication, November 1994). About two-thirds of all U.S. croplands are enrolled in these programs (Economic Research Service 1991). Management practices and land-use decisions of farmers tilling this land have been strongly influenced by commodity program incentives and regulations that mandate how land can be used by participating farmers. Policy relating to these programs may be the major means by which the U.S. Government influences the agricultural practices of farmers (Sampson 1981; National Research Council 1989; Doering 1992).

Many factors contribute to agriculturally related habitat loss. However, federal commodity programs, particularly those that influence the total land in active production, have resulted in significant changes in habitat quality and availability and changes in the distribution and abundance of many species (Berner 1988). These "land retirement" or "set-aside" programs have been a central component of federal agricultural commodity policies since 1934 and have influenced the quality and distribution of millions of hectares of wildlife habitat.

[3] Commodity crops include wheat, corn, soybeans, oats (*Avena sativa*), cotton (*Gossypium* spp.), barley (*Hordeum* spp.), rice (*Oryza sativa*), sorghum, sugar, peanuts (*Arachis hypogaea*), tobacco (*Nicotiana tabacum*), and milk.

During the 1930's the Soil Conservation Service (SCS) and the Agricultural Stabilization and Conservation Service (ASCS) were created, and the Cropland Adjustment Act and Agricultural Conservation Program idled up to 16 million hectares annually.

In 1956 overproduction and low farm income created the political energy necessary to initiate the Soil Bank program. This program had two options, an annual option, called the Acreage Reserve, and a 3-, 5-, and 10-year land retirement option called the Conservation Reserve. Compensation under the Conservation Reserve was relatively low. The USDA had difficulty controlling overproduction because farmers in more productive areas were unwilling to participate. In addition, agricultural policy makers argued that multiyear programs reduced the flexibility of the government's response to market fluctuations. As a result, a shift to annual programs occurred, such as the Emergency Feed Grain Program of 1961 and the wheat, cotton, and rice programs of 1962 (Sampson 1981).

In 1966 the Cropland Adjustment Program (CAP) was created to retire cropland under 10-year agreements. Because the annual programs were still in effect and involved higher compensation, this program was relatively unpopular (Sampson 1981).

From 1966 to 1985, annual emergency feed grain programs, wheat programs, and the cotton and rice programs continued within other farm bills. These programs carried benefits that encouraged the development of new land to produce more commodity crops, which destroyed critical prairie grassland and wetland habitats. In addition, these programs promoted the development of dangerous habitat because program regulations often required that cover crops be destroyed during a period when many species use these lands for nesting and brooding (Sampson 1981; Berner 1988).

Concern over the expense of earlier land-idling programs (an exceptional high of $9.3 billion in 1983 (U.S. Department of Agriculture 1991c), aggravation of soil erosion problems, effects on wildlife populations, and continued plowing of fragile grasslands and wetlands led to demands for stronger conservation components in federal agriculture policy (Cook 1985). Fish and wildlife conservation groups, environmental organizations, and farmland conservation activists worked together to lobby for strong resource conservation regulations for inclusion in the farm act. Their efforts resulted in passage of the strongest conservation provisions in the history of U.S. agricultural legislation—the Food Security Act (FSA) of 1985. This act contained unusually strict environmental regulations, restricting benefits to farmers who did not comply with specified conservation standards. The so called "Swampbuster" and "Sodbuster" amendments denied benefits to and levied penalties on farmers who drained wetlands or cultivated highly erodible lands. The Conservation Reserve Program (CRP) was initiated to enroll, over a 10-year period, up to 18.2 million ha of certain highly erodible lands in 10–15-year retirement contracts (Cohen 1991). Annual hectarage retirement programs continued under the Acreage Reduction Program.

The Food, Agriculture, Conservation and Trade Act (FACTA) of 1990 increased emphasis on the protection of soil and water resources. This act attached to the CRP a new Wetlands Reserve Program, a voluntary USDA easement program to restore and protect wetlands. The Integrated Farm Management Program was added to encourage (not require) the planting of resource-conserving crops on commodity-base lands.

The area of land in annual and long-term land-idling programs relative to the total U.S. cropland base since 1956 is displayed in Fig. 2.

Cropland Retirement Programs and Wildlife Populations

Obviously, a change in habitat area and quality is created by these programs. For some species profound population declines occurred before these programs were implemented. In the past 3 decades, however, reductions in habitat quantity and quality resulting from these programs were probable factors in the declines of many wildlife populations. Specific aspects of federal cropland-idling programs contributing to habitat loss and wildlife population declines are described below.

Annual Programs and Regulations Governing the Management of Idled Lands

During many of the past 60 years, the USDA has attempted to control surplus production of commodity crops through various incentives that encourage farmers to set aside portions of their land where no commodity crops are planted. Lands set aside under some programs provided beneficial wildlife habitat. Some programs, requiring contracts stipulating multiyear retirement under a permanent grass cover, resulted in significant amounts of quality nesting cover (Berner 1988). However, in terms of total hectares retired since 1963, longer-term programs have been superseded by annual programs that generally provided greater financial returns to the farmer. Because the growth of cover crops is often limited so that little or no vegetation is established, these programs tend to result in vegetative structure less than ideal for many species of wildlife that require dense grass or grass and shrub cover (Berner 1988). Up to 60% of annual set aside lands have been left unseeded or are tilled regularly for summer fallow (Jahn and Schenck 1990). Regulations relating to cover crops on annual

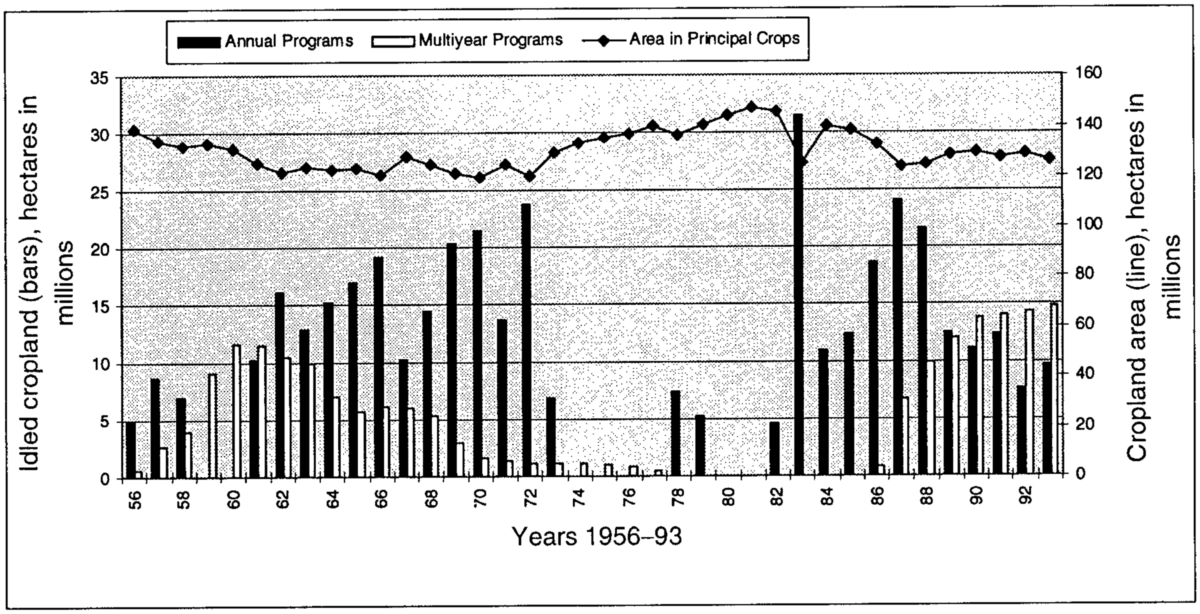

Fig. 2. Historical distribution of area enrolled in the Department of Agriculture annual and multiyear cropland idling programs (*bar graph*), with *overlay line* representing hectares planted to principal crops. Sources: Annual and multiyear programs = Berner 1988; Agricultural Stabilization and Conservation Service personal communication. Area in principal crops = *Agricultural Statistics* 1971, 1978, 1992, United States Department of Agriculture, United States Government Printing Office, Washington, D.C.; Agricultural Stabilization and Conservation Service personal communication.

contract lands encouraged practices detrimental to nesting wildlife. For example, late seeding has been allowed, and destruction of vegetative cover is required by mowing, disking, or plowing. The control of vegetative cover is carried out to control weeds and to make certain that planted small-grain cover crops are not harvested for seed. To continue to receive payment for land enrolled in these programs, the destruction of cover is often required at a time that coincides with the nesting season of many grassland species, destroying many nesting and brooding animals (Berner 1988; Kimmel et al. 1992; Allen 1993b; Berner 1994).

Base-acreage[4] and Established Yield Regulations

Before the 1985 farm bill most land retirement and all crop price and income support programs were organized around a set base-acreage planted to a given commodity with an established yield for that area. Generally, crop area planted and enrolled, plus average individual or county yields obtained during the previous 5 years, formed the basis for benefits received. A farmer thinking about decreasing the area he planted in a commodity crop would have to consider giving up benefits for that year, as well as losing future benefits by reducing the next 5-year average of his eligible base.

A significant portion of federal payments to farmers is in the form of deficiency payments, which make up the difference between a target price and the market price. The per-acre-payment is based on the farmer's established yield. It has been argued that where deficiency payments increased as yields increased, farmers tended to push for maximum production to the detriment of soil stability and farm wildlife (Cook 1985; Berner 1988).

Because potential program payments were related to the area planted in program crops in preceding years, financial incentive encouraged the expansion of program crop area. In many parts of the country this expansion involved draining and plowing wetlands or plowing native grasslands or pasture that had provided rich wildlife habitat (Berner 1988; Jahn and Schenck 1991) The 1985 farm bill halted the addition of base-acres and froze program yields, which has removed these incentives for plowing new lands or jacking-up crop yields beyond economically justifiable returns. Similarly, before 1985, benefits tended to be higher for those farmers who planted program crops on the same fields year after year because the annual programs tended to discourage the planting of habitat-enhancing crops such as hay or small grains (National Research Council 1989). Current programs allow farmers to plant a portion of their base-acres to whatever crops they want and not lose any of their base.

[4] In keeping with commonly accepted regulatory language the terms base-acres and per-acre-payments will be used rather than coining metric equivalents.

Lack of Continuity

Because most programs are effective annually and rules and benefits regularly change, biologists find it difficult to help farmers plan operations and field locations in ways that might benefit wildlife.

Program Administration

The formulation and administration of conservation guidelines for these programs are left to state and local committees, usually composed of local farmers, with no requirement or expectation for inclusion of fish and wildlife or other natural resource conservation personnel (Berner 1988; Allen 1993b).

Wildlife and the Conservation Reserve Program

Private wildlife conservation organizations, as well as the U.S. Fish and Wildlife Service, have been particularly enthusiastic about the potential wildlife benefits of the Conservation Reserve Program. The extent of land involved and the relatively long-term contracts promised to provide extensive areas of high quality wildlife habitat. The CRP has been considered one of the most important programs for wildlife conservation established by the USDA (Berner 1988; Allen 1993b; Dunn et al. 1993; Cook 1994).

After 9 years, how does the CRP measure up? In several regions the program is perceived to have significantly benefited wildlife (Allen 1993b). However, relatively few published studies on affected populations are available. The next section of this report describes several of these studies, in particular a study on the effects of the CRP on grassland birds populations in the Great Plains region.

Grassland Breeding Birds and the Conservation Reserve Program

Grassland bird species have shown steep, consistent, and geographically widespread declines over the past 25 years, more dramatic than any other guild of North American avifauna, including neotropical migrants (Graber and Graber 1983; Berner 1988; Knopf 1995). The problems that have led to the declines of grassland breeding birds are associated almost entirely with North American processes, as many of these species also winter on the continent (Knopf 1995). Numbers of lark buntings (*Calamospiza melanocorys*) and grasshopper sparrows, for example, declined by half during the past 3 decades according to the U.S. Fish and Wildlife Service's *Breeding Bird Survey* (Johnson and Schwartz 1993). Censuses carried out in Illinois in 1978–79 by Drs. Jean and Richard Graber of the Illinois Natural History Survey indicated that population densities of representative grassland species, within the range characterized by all prairie species in Illinois, had fallen 80–90% below those from a 1957–58 census (Graber and Graber 1983; see Table 2).

According to U.S. Fish and Wildlife *Breeding Bird Surveys* for 1966–90, 7 of the 10 endemic grassland bird species showed population declines, and 16 of the 25 grassland species of more widespread distribution also declined during this period (Knopf 1995).

Agricultural Factors Driving Population Declines

The reason why so many species have declined is unknown, and the problem is difficult to assess. However, wildlife biologists whose work I reviewed consider that these declines occurred in close association with the conversion of perennial grassland habitats into annually tilled cropland, the expansion in lands planted to row-crops, the clearing of field edge verges to allow enlargement of existing fields, and other landscape or cropland changes (Berner 1988; Robinson 1991; Allen 1993b; Johnson and Schwartz 1993; Knopf 1995). These changes may have created farmland lacking the food, shelter, or nesting sites needed to attract and sustain these species (Rodenhouse et al. 1992).

Research on bird populations in Illinois provides important insight into the relation between agricultural practices and avian population declines. Relatively comprehensive population studies provide baseline information, and Illinois was an early adopter of modern agricultural practices that have spread to many other U.S. farming regions (Warner 1994). Graber and Graber (1983, p.1) reported that until 1959 prairie songbird populations were "remarkably preserved, considering that the original

Table 2. Population change in eight grassland bird species in Illinois over a 25-year period, 1957–58 to 1983 (from Graber and Graber 1983).

Species	Percent change
Upland sandpiper *Bartramia longicauda*	–92
Bobolink *Dolichonyx oryzivorus*	–97
Meadowlarks (2 spp.) *Sturnella* spp.	–84
Dickcissel *Spiza americana*	–96
Savannah sparrow *Passerculus sandwichensis*	–98
Grasshopper sparrow *Ammodramus savannarum*	–96
Henslow's sparrow *Passerherbulus henslowii*	–94

prairie was all but gone." Many grassland birds appear to define their breeding area niches in terms of habitat structure (Wiens and Dyer 1975; Berner 1988; Kimmel et al. 1992), rather than with certain species or floristic communities. Perhaps that is why many of these species were found at relatively high densities prior to the 1960's. Surveys in 1957–58 showed breeding populations of prairie song birds as numerous as in 1906–09. After the 1960's the area of these managed grasslands dropped sharply. In Illinois this decrease in managed grasslands was as much as 50% per decade from the 1960's through the 1980's (Graber and Graber 1983). In Illinois, as conventional cash-grain farming increased in an area, field size more than doubled, and fencerows and other waste areas decreased. The declines in prairie avifauna have corresponded with these and other shifts in agricultural practices (Herkert 1991). During this period prairie-chickens, already in decline (Warner 1994), disappeared, and northern bobwhite declined by 78% (Vance 1976). In a study by Mankin (1993), the index for eastern cottontail (*Sylvilagus floridanus*) abundance in eastern Illinois decreased by 40% between 1956 and 1989, which correlated with the loss of land in hay and pasture.

The Conservation Reserve Program and Changes in the Abundance of Grassland Birds

If there is a correlation between the trend toward increased area in row crops, decrease in crop vegetative diversity, and loss of wetland and grassland and the decline of grassland breeding bird species, then reversing these trends should reduce population declines. A test of this correlation has occurred with implementation of the Conservation Reserve Program. If the CRP restores suitable habitat for these declining species, then the population declines should slow or stop.

As of 1993 the regions with the largest percentage of farmlands enrolled in the CRP were the Midwest and Great Plains. Wildlife response to the CRP within these regions is perceived to be almost universally positive. Much of the broad regional information on the effects of the CRP on wildlife has been about gamebird populations. For example, North Dakota's ring-necked pheasant harvest is now the highest since the early 1960's. Minnesota, Iowa, Illinois, Nebraska, and Kansas have all reported increased populations of pheasant or northern bobwhite in association with the CRP (Allen 1993b). In a particularly CRP-rich area of Iowa, pheasant numbers increased 13-fold compared with pre-CRP abundance (Berner 1994). A study conducted in North Dakota indicated that CRP fields were beneficial to most upland waterfowl (Kantrud et al. 1993).

In 1988 the National Ecology Research Center of the U.S. Fish and Wildlife Service (now the Midcontinent Ecological Science Center of the National Biological Service), in Fort Collins, Colorado, began coordinating a CRP evaluation project. The project, involving the participation of more than 30 states, proposed to evaluate changes in habitat quality and quantity for three regional wildlife species. In each region two game and one nongame species were selected, for example, ring-neck pheasant (*Phasianus colchicus*), meadowlarks (*Sturnella* spp.), and cottontail for the midwest states (Hays et al. 1989). With some exceptions, reports to date indicate that the CRP is providing substantial benefits to many wildlife species (Allen 1993b). This study used habitat suitability models, derived from an evaluation of the ability of key habitat components to supply the life requisites of study species (U.S. Fish and Wildlife Service 1980), to measure habitat changes related to the CRP. With a habitat suitability index of 1 being optimum, the CRP has improved habitat quality for pheasants from 0.01 to 0.6, for meadowlarks from 0.01 to 0.35, and for cottontails from 0.01 to 0.1. (Berner 1994).

Johnson and Schwartz (1993) conducted a study on the response of grassland birds to the CRP in eastern Montana, North Dakota, South Dakota, and western Minnesota. Their work indicated that several prairie species whose populations had declined dramatically between 1966 and 1990 were common in CRP fields. They recorded 73 species of birds in the CRP fields surveyed. The first, second, eighth, ninth, 17th, and 18th most abundant species in their survey of CRP fields showed significant regional or national downward trends in abundance (Table 3). In fact, the two most common species that they found in CRP fields, the lark bunting and grasshopper sparrow, declined by more than 4% annually, regionally and continentally, over the 24-year period. Populations of clay-colored sparrow, bobolink, dickcissel, and Baird's sparrow declined annually in the Central Region (between the Rocky Mountains and the Mississippi River) by about 2%, 2.7%, 1.5%, and 2.5% respectively. Yet these species, as well as other less threatened species, were relatively common in the CRP fields surveyed. In fact, the densities of 16 of the 20 most abundant species they recorded were seven times greater (the median) in the CRP fields than in an earlier bird population survey of croplands. Although research on the habitat provided by the CRP in the Great Plains is limited, the abundance of bird species on some CRP lands indicates that the habitat provided can be of tremendous value to grassland breeding birds.

Endangered Species

The CRP's contributions toward increasing the habitat for endangered or threatened species has received less attention than its benefits for popular game and relatively abundant nongame species. Nonetheless, the CRP has the potential to prevent further declines of threatened species

Table 3. Densities of breeding birds (pairs/100 ha) in Conservation Reserve Program field surveys, conducted in 1990 and 1991, in eastern Montana, North Dakota, South Dakota, and western Minnesota listed in order of average abundance. Trends in abundance for these species estimated from 1966 to 1990 U.S. Fish and Wildlife Service *Breeding Bird Surveys.* Densities of breeding birds on cropland are from an earlier survey (Johnson and Schwartz 1993, Table 1).

Species	Average density	CRP fields		Average annual change (%)	
	Cropland	1990	1991	Central region	Continental
Lark bunting *Calamospiza melanocorys*	4.2	23.1	21.8	−4.22***	−4.17 ***
Grasshopper sparrow *Ammodramus savannarum*	0.5	21.9	20.4	−4.58 ***	−4.47 ***
Red-winged blackbird *Agelaius phoeniceus*	1.1	13.4	19.3	−0.04	−0.88
Western meadowlark *Sturnella neglecta*	4.3	8.4	7.3	−0.34	−0.72
Horned lark *Eremophila alpestris*	18.0	9.1	5.5	−0.15	−0.62
Savannah sparrow *Passerculus sandwichiensis*	1.9	6.8	5.4	0.63	−0.63
Brown-headed cowbird *Molothrus ater*	2.7	4.1	6.9	−0.26	−0.87 *
Clay-colored sparrow *Spizella pallida*	0	3.8	5.1	−2.08 *	−1.53 **
Bobolink *Dolichonyx oryzivorus*	1.5	3.4	5.1	−2.74 ***	−0.95
Common yellowthroat *Geothlypis trichas*	0	2.2	4.4	−0.32	−0.38
Sedge wren *Cistothorus platensis*	0	3.0	2.1	−0.97	1.31
Chestnut-collared longspur *Calcarius ornatus*	5	3.0	1.6	−0.47	0.38
Eastern kingbird *Tyrannus tyrannus*	0.2	1.9	2.2	0.43	−0.08
Western kingbird *Tyrannus verticalis*	0.3	1.8	1.9	1.82 ***	1.59 ***
Barn swallow *Hirundo rustica*	0.3	2.0	1.6	2.49 ***	0.98 **
Mourning dove *Zenaida macroura*	1.3	1.9	1.5	−0.07	0.06
Dickcissel *Spiza americana*	0.2	1.9	1.4	−1.44 **	−1.61 **
Baird's sparrow *Ammodramus bairdii*	0	1.6	1.7	−2.58 **	−1.90 *
Vesper sparrow *Pooecetes gramineus*	1.2	0.6	0.8	0.24	−0.85
Killdeer *Charadrius vociferus*	1.1	0.4	0.5	0.25	0.27

Note: *P<0.10; **P<0.5; ***P<0.1.

that depend on prairie-like grasslands, especially if the appropriate conservation practices are established (Allen 1993b).

In 1984, Colorado populations of the greater prairie-chicken were down to about 2,000 individuals, and the bird was put on the state's endangered species list. In November 1993 the bird was delisted to a threatened status, and populations are now approaching 20,000 birds. This recovery is directly linked to habitat provided by the Conservation Reserve Program (Gordon East, Colorado Division of Wildlife, Denver, personal communication). The greater prairie-chicken, considered an

indicator of grassland ecosystem health, has also been on the Minnesota species of concern list. In 1992 the counts of breeding cocks in Minnesota were the highest recorded in 50–60 years, although the total increase in population has not been as dramatic as in Colorado (John Tropfer, North Dakota Division of Fish and Wildlife, Fort Totton, personal communication).

Several of the species observed in Johnson and Schwartz's 1993 study are on species of concern lists in the study region, and the CRP does seem to offer an increase in breeding habitat for these birds. According to Allen (1993b) the CRP has directly or indirectly provided some benefits, and could potentially provide much greater benefits, for several rare or endangered Great Plains and midwestern species. These include the least tern (*Sterna antillarum*), piping plover (*Charadrius melodus*), upland sandpiper, loggerhead shrike (*Lanius ludovicianus*), whooping crane (*Grus americana*), bald eagle (*Haliaeetus leucocephalus*), common barn-owl (*Tyto alba*), short-eared owl (*Asio flammeus*), northern harrier (*Circus cyaneus*), peregrine falcon (*Falco peregrinus*), and pallid sturgeon (*Scaphirhynchus albus*). In the Southeast, the Bewick's wren (*Thryomanes bewickii*), Bachman's sparrow (*Aimophila aestivalis*), Henslow's sparrow (*Ammodramus henslowii*), and grasshopper sparrow, are threatened or endangered avian species that have benefitted from habitat developed through the CRP. Endangered fish and mollusc species are also likely to benefit from the increased use of filter strips, a conservation practice option under the CRP (Allen 1993b).

The 1985 and 1990 farm bills elicited an unusual level of interest, involvement, and debate among wildlife biologists and conservationists. In particular, the CRP was seen as a program with tremendous potential for wildlife conservation. A critical examination of how CRP implementation to date has taken advantage of this potential is useful. Information and experience gained from the CRP may be used to develop future programs that will conserve biological diversity in the agricultural landscape.

Implementation of the Conservation Reserve Program

Cropland or pastureland proposed for enrollment in the CRP must satisfy certain wetland or soil erosion criteria. The ASCS committees are expected to evaluate these proposals using an "Environmental Benefits Index." This index includes water, soil quality, conservation priority areas, and other factors (U.S. Department of Agriculture 1991a; wildlife considerations are being considered as part of an updated environmental benefits index.) If accepted in the program, the CRP pays the farmer rent on the enrolled lands for a 10–15-year contract. The farmer must establish permanent cover and manage it for this period under specific guidelines. The ASCS will provide up to a 50% "cost-share" for establishing this cover. Specific practices are approved for establishing vegetative cover on these lands. Local ASCS committees are free to choose, from a Department of Agriculture list (examples in Table 4), which practices they will fund (U.S. Department of Agriculture 1991a). As of June of 1992 (the last sign-up date for this program) 14,740,093 ha, representing about 10% of U.S. cropland, had been enrolled (U.S. Department of Agriculture 1991c; Agricultural Stabilization and Conservation Service 1993).

Table 4. Selected conservation practices[a] eligible for Agricultural Stabilization and Conservation Service funds and their relative use on all Conservation Reserve Program lands as of 19 July 1991 (from Allen 1993b, p.15; and Berner 1988).

Conservation practice	% of total CRP acres	Cover established
CP 1	58.4	Domestic grasses
CP 2	23.4	Native grasses
CP 3	6.2	Tree planting
CP 4	5.5	Permanent wildlife habitat
CP 5,16	0.02	Shelterbelts, windbreaks, rows of trees/shrubs
CP 8, 13,15	0.20	Filter and grass contour strips, grass waterways
CP 9	0.03	Shallow water areas for wildlife
CP 10	5.35	Maintenance of already established grass cover, planted or naturally occurring

[a] The remaining conservation practices, including establishing wildlife food plots, wetland trees, and erosion control structures, account for less than 2% of total CRP area.

Biological Issues in Conservation Practice Selection and Management

According to Allen (1993b), wildlife biologists are particularly concerned with five aspects of the establishment and management of permanent cover on CRP lands. These concerns relate to tree planting, establishment of filter strips, planting and management of grasses, weed control, and haying and grazing.

Tree Planting

By 1992, 6.2% of CRP lands were planted to trees. More than 86% of all trees planted on CRP lands were loblolly pine (*Pinus taeda*) or slash pine (*P. Elliottii*). Although trees can provide high quality habitat, wildlife biologists agree that when pine replaces hardwoods or cropland, lower quality wildlife habitat usually is the result. Plantation planting densities, coupled with the growth habit of pine, result in loss of understory herbaceous species and an environment of relatively low habitat value. Tree plantings could be managed in many ways to improve their value to wildlife. In general, hardwoods are superior to softwoods. However, other native softwood species, varied plant spacings, species diversification, and leaving spaces for herbaceous cover could also provide better habitat values.

Establishment of Filter Strips

Only 0.2% of all CRP lands are filter strips, yet this practice has the potential to increase habitat complexity and potential nesting cover. This linear habitat feature, comprising grassed strips at the edges of fields and drainage areas, created to reduce soil or chemical runoff, is usually left untouched once established. Filter strips can provide cover when other farmland grass areas are harvested by livestock or for hay. Several biologists I interviewed suggested that filter strips, because they remain relatively undisturbed, could play a valuable role in farm wildlife habitat enhancement.

Planting and Management of Grasses

As of 1991, almost 82% of all CRP lands were planted to grasses (Table 3). More than 70% of the lands planted to grass were seeded with domesticated or non-native grasses. However, many wildlife biologists think that native grasses provide superior habitat compared with introduced grasses (although in some areas it was difficult for farmers to find adequate or reasonably priced supplies of native grass seeds [Allen 1993b]). A requirement to plant native grasses or the more favorable (warm season) introduced grasses would greatly increase wildlife benefits (Berner 1988; Allen 1993b). In addition, CRP grass plantings should be of multiple species to increase habitat diversity. Single-species plantings of fescue (*Festuca* sp.) in the southeastern states have provided essentially no diversity in vegetative structure and species composition, hence only limited habitat. Fescue stands become so dense 1–3 years after planting that they preclude use by grassland nesting birds (Allen 1993b).

Changes in species composition or physical structure over time affect habitat quality even in grasslands with optimal, diverse species compositions. Over a period of years the habitat quality in grassland CRP fields may decrease for upland nesting birds due to accumulation of litter or the increased density of the stand. Historically, disturbance in the form of fire and the random movement of large herds of grazing animals maintained long-term habitat quality in grasslands. Periodic disturbance by disking or burning of planted grasslands will increase vegetation height and vigor and maintain desirable vegetative species composition (Al Berner, Minnesota Department of Natural Resources, Madelia, personal communication).

Weed Control

Historically, a condition for ASCS-supported establishment of grasses has been that early mowing must be carried out to suppress weeds. On annual program fields, the justification for this mowing has been the reduction of weed problems. Requiring the destruction of weeds before they set seed, by mowing, disking, or the application of herbicide, avoided situations where ASCS programs might be seen as perpetrators of poor farming practices. This concern about weed control has been carried over to CRP lands. Of primary concern to wildlife biologists is that mowing is still the most common form of weed control and that mowing during the prime reproductive period for ground-nesting birds (April through July) results in destruction of nests, broods, or hens. An additional concern is that mowing may eliminate annual species of flora that are beneficial to wildlife (Berner 1988).

Haying and Grazing

Mowing CRP fields for hay, which is allowed under certain circumstances (allowed in 7 of 8 years from 1985 to 1992), has similar effects on wildlife as mowing for weed control. Light grazing may be compatible with the use of CRP lands with some species of grassland birds (Allen 1993b), but heavy grazing may produce many of the same effects as mowing. An emergency forage reserve could be made available on annual set-aside lands, rather than on long-term CRP lands.

Conservation Reserve Program Administrative Issues

The Conservation Reserve Program is administered by the Agricultural Stabilization and Conservation Service (ASCS), which has never been (and makes no pretensions of becoming) a wildlife conservation service. This fact alone has been adequate to create tensions between the historical mission of the ASCS and the wildlife concerns associated

with the CRP. Collaboration between the ASCS and wildlife agencies and public education efforts have become central issues.

Collaboration Between Agencies

For CRP fields to approach their potential as wildlife habitat, Department of Agriculture and state fish and wildlife professionals must work together. According to Allen (1993b), a direct connection existed between the CRP's perceived or actual values to wildlife and how well personnel from the different agencies worked together managing the program. Problems with interagency cooperation at the county level occurred as a result of differences between the authority of Department of Agriculture and Fish and Wildlife personnel. For example, local ASCS committees hold most of the control over which conservation practices are implemented and how they are managed. National directives also cause problems, as when the USDA limited the use of "Conservation Practice 4" (permanent wildlife habitat) to no more than 10% of an individual CRP enrollment.

Public Education

According to several surveys, more than two-thirds of CRP contractees responded that wildlife considerations influenced their choice of conservation practices (Miller and Bromley 1989; Kurzejeski et al. 1992; Allen 1993b). In one survey, however, 62% of respondents indicated that they had not received information about options that would specifically enhance habitat quality.

The nonfarming public also has received little or no education as to the wildlife or general environmental benefits of this extraordinarily large-scale and long-term program.

Increasing the Biological Conservation Benefits of the Conservation Reserve Program

Preliminary research, as characterized by Johnson and Schwartz's (1993) work on grassland birds, indicates that the CRP has increased the extent and quality of wildlife habitat in certain agricultural landscapes. However, even within regions where the program has been perceived as beneficial to wildlife, biologists agree that the full potential of the program has not been realized (Allen 1993a, 1993b). The most common criticisms of the CRP from state and federal biologists across the United States are as follows:

1. excessive mowing of CRP fields,
2. insufficient information or assistance provided by ASCS or SCS personnel regarding wildlife habitat management,
3. limited acceptance and use (in some regions) of authorized conservation practices with the greatest potential for wildlife,
4. inflexibility on the part of ASCS to carry out management actions to maintain or improve habitat quality on CRP lands, and
5. abuse of emergency haying provisions (from Allen 1993b).

Many critics also think that the CRP has not been targeted regionally to provide maximum benefits to wildlife (Cook 1994). To address criticisms of the CRP, biologists suggested several modifications, which are listed in Table 5 (from Allen 1993b).

Barriers to Increasing the Wildlife Conservation Benefits of the Conservation Reserve Program

The recommendations for changes to the CRP outlined in Table 5 make sense from a wildlife biology perspective. However, several critical factors, not necessarily associated with wildlife biology, will affect the potential implementation of these recommendations. These factors involve problems or issues with federal funding, the development of conservation objectives, water and soil resource management priorities, farm management, and the motivation of farmers.

Federal Funding

The CRP is not cheap. Since 1985, the ASCS has provided farmers with more than $1.3 billion in cost-share payments to support establishment of conservation practices on CRP lands (Agricultural Stabilization and Conservation Service 1993). Rental payments, averaging $122.73/ha, cost the government almost $1.8 billion in 1993 (Center For Resource Economics 1992; Agricultural Stabilization and Conservation Service, personal communication). Estimated total cost for 1987–2003 is $19.2 billion (Allen 1993b). The Department of Agriculture budget for 1993 was $67.85 billion (U.S. Department of Agriculture Information Center, personal communication). Therefore, the current $1.8 billion annual cost for the CRP represents about 3% of the Department of Agriculture's annual budget.

Maintaining long-term full enrollment in the CRP may actually increase farm income and reduce government spending (Young et al. 1994). The potential exists for billions of dollars worth of natural resource benefits (Ribaudo et al. 1989). However, as Jahn and Schenck (1990, p. 362) stated, "As long as commodity stocks are low, market prices strong and corresponding federal support payments reduced, the CRP's budget will remain under close scrutiny." The increased production of commodities that might occur with a reduction in the scale of the CRP might be countered by an increased emphasis on annual programs. The detrimental effects of these annual programs on farm wildlife were described in previous sections.

Table 5. Biologists' recommendations for modifying the Conservation Reserve Program (from Allen 1993b, pp. 21–23).

1. Control of undesirable vegetation should be constrained to state-defined noxious species and limited to site-specific spot treatments rather than across entire fields as a preventative measure.
2. All mowing of CRP fields should be prohibited during the prime reproductive period for ground-nesting birds (April 1 to July 31).
3. Regional CRP and set-aside guidelines should be defined to address regional and local wildlife priorities.
4. Greater diversity in implementing individual conservation practices and increased flexibility in seed mixtures should be encouraged.
5. Strip disking, prescribed burning, or other management options that prevent invasion of woody species in grasslands, maintain vegetation vigor and desirable species composition, and encourage growth of beneficial annual vegetation should be permitted.
6. Contracts planted to tame grass (CP1) or native grass (CP2) that provide the greatest wildlife benefits should be identified and given priority for contract continuation over less desirable contracts.
7. If CP1 or CP2 contracts are extended, larger fields should receive priority over smaller fields.
8. Priority should be placed on the following conservation practices for extension following expiration of current contracts:

   CP2 - Native grasses
   CP9 - Shallow water areas for wildlife
   CP3 - Tree planting (especially hardwoods)
   CP4 - Permanent wildlife habitat
   CP7 - Erosion control structures
   CP12 - Wildlife food plots
   CP13 - Filter strips
   CP14 - Wetland trees

9. Wildlife openings should be a mandatory requirement in large, CRP-funded pine plantations.
10. If additional lands are enrolled in the CRP, management of CP3 and CP4 should be oriented toward restoring vegetative composition to maximize structural diversity and species composition that more closely reflects conditions in native vegetative communities.
11. A top down (federal, state, county) approach to formulating policy and enforcing conservation practices should be established. This approach will allow increased flexibility and cooperation at the local ASCS level and minimize differences in program implementation across county boundaries.
12. The amount of technical assistance provided by state wildlife agency personnel to USDA staff responsible for on-ground management of the CRP and contractees should be increased substantially.
13. Funding should be provided to implement a state-federal agency team approach to CRP plan writing, similar to the Forest Stewardship Program.
14. State Technical Committees should be implemented and should be allowed regional flexibility in specifying conservation practices applied.
15. USDA agencies involved in administering the CRP should increase funding and priority for the education of county agents. This training should focus on implementing conservation practices and management options that reflect landowner objectives for enhancing wildlife habitat.
16. The amount of cost-share provided to contractees to increase landowner interest and ability to improve wildlife habitat should be increased.
17. The amount of cost-share for planting hardwood trees and grasses in filter strips should be increased 100% and 75%, respectively.
18. The maximum permissible width of filter strips should be increased from 1 1/2 to 2 chains. (1 chain = 20.1 m).
19. A minimum of 20% of new contracts should be required to include conservation practices that benefit wildlife. These practices should be defined by state conservation review committees to reflect regional or local priorities.
20. Financial incentives should be provided for state agencies to become more involved in technical assistance and implementation of the CRP.

Conservation Objectives

The interest in the value of CRP lands for wildlife has predominantly centered on species typically associated with agricultural landscapes (Berner 1988; Knopf 1995), including game species such as cottontails, ring-necked pheasant, and northern bobwhite. But the CRP also has been perceived as a program to protect and enhance habitat for endangered or threatened nongame species. However, in meeting the habitat requirements of endangered species, the habitat quality or availability for species more commonly associated with agricultural ecosystems may be reduced (Allen 1993b). For example, establishing woody cover in the form of shelterbelts may increase the abundance and diversity of wildlife, especially in a landscape dominated by cropland. However, this habitat may allow for increased predation or nest parasitism of threatened or endangered upland nesting species (Allen 1993b). Conversely, meeting the habitat needs of endangered or threatened species through the establishment of large contiguous blocks of CRP lands might reduce the habitat quality for farmland wildlife, which depend on greater vegetative diversity or more interspersion between vegetative associations (Harris and Woolard 1990; Macdonald and Smith 1990).

In fact, using the CRP to benefit threatened wildlife species is logistically and politically difficult. Many vertebrates with the highest need of conservation action may require relatively large, contiguous areas of suitable habitat (Noss and Cooperider 1994). The multiple, disjunct areas of similar habitat characteristic of CRP lands, even if of equal area, might provide inadequate habitat for these species (Knopf 1995). How will conflicts over species conservation objectives, many of which will require multicommittee consensus, be resolved? A regional conservation plan to protect endangered or threatened species may not be possible given the constraints of a voluntary program.

Regardless of how these issues are resolved, local and regional species conservation objectives are essential and must be established to derive the maximum benefits to species of concern.

Water and Soil Resource Management Priorities

The CRP is principally a program to reduce commodity surpluses and to conserve soil and water resources. Any use of the land other than growing commodity crops will serve the former function, and there are many practices that have equal value in the conservation of soil and water. However, the different soil and water conservation practices do not necessarily result in habitat of equal value. When the CRP was first established, wildlife biologists felt that, regardless of the objectives of the policy, the program had great potential for wildlife (Cook 1985; Berner 1988; Jan and Schenck 1990; Robinson 1991). Clearly, the interest exists for expanding this potential. However, how far can this potential be expanded before running into (perceived or actual) conflict within the existing context of the CRP? How high a priority are wildlife habitat values compared with the conservation of soil and water resources? Are cost share programs that simply address soil and water conservation concerns less expensive than those that also enhance wildlife habitat? Will farmers with strong interest in soil and water conservation but little interest in wildlife conservation be selected against in the bidding process?

Farm Management

Managing for increased wildlife habitat may often dovetail with soil and water conservation practices but may not easily fit in with the management practices of participating farmers. Four farm management issues must be acknowledged: (1) many farmers have spent decades trying to reduce the weed-seed bank in their cropland soils. They would need assurance that losses in yields due to weeds, noxious or otherwise, will not increase; (2) without additional or longer-term compensation many farmers would be resistant to establishing cover that would make reconversion to cropland difficult; (3) farmers often manage complex operations requiring a high input of physical and organizational effort. Because their efforts are focused on crop production, wildlife habitat cover requiring more than minimal maintenance may be neglected; and (4) converting cropland to CRP (or CRP back to cropland) may increase crop depredation by animals that make use of CRP lands (Allen 1993b). Certain wildlife carry diseases that may be transmitted to livestock. Farmers participating in a wildlife oriented CRP must be assured that they will not be increasing their risk of crop or livestock losses.

Motivation and Interest of Farmers

Although surveys have shown that farmers are interested in providing wildlife habitat, wildlife interests are not usually a primary concern when land is enrolled in the CRP. For example, a survey in Iowa (n = 120), asked farmers if they would like to improve wildlife habitat on their (already) retired lands; 73.5% answered yes (Miller and Bromley 1989). In another survey in Missouri (n = 1,715), however, only 11.9% of farmers claimed that providing habitat was their most important reason for enrolling lands in the CRP, while 37.3% felt that wildlife was of some importance affecting their decision (Kurzejewski et al. 1992). Will a soil and water conservation program, expanded to include the development of wildlife habitat, be successful given this level of interest? After all of the appropriations are made and regional policy agreed

on, the activities of the farmer still constitute the final and effective implementation of the program. Interest in managing land for wildlife may be increased by offering higher rental or cost share payments or the purchase of permanent wildlife habitat easements. But this strategy may cost more than the establishment of soil and water conservation measures, and, at least on a broad scale, adequate funds probably would not be available.

Improving the wildlife benefits of the CRP is complicated by difficult and sometimes conflicting issues. However, the potential of this program to increase the abundance and viability of wildlife remains enormous (Thomas 1990; Kimmel et al. 1992; Allen 1993b; Berner 1994). Because of involvement by wildlife professionals and conservation groups, the CRP is the first large-scale, comprehensive attempt at incorporating wildlife conservation concerns into an agricultural conservation program. Experience gained at all levels—program development, implementation, and research—will be of value in future attempts to enhance wildlife habitat in the agricultural landscape.

Farm Policy Recommendations

Conservation Reserve Program

A fundamental barrier exists regarding the incorporation of wildlife biologists' suggestions for the CRP into the 1995 farm bill: The conservation of wildlife is not an explicit concern of the Conservation Reserve Program. Although occasional references to wildlife are found in the CRP chapter, and two of the conservation practices eligible for cost-sharing are wildlife associated, the CRP is not meant to be a habitat development program. The most effective change that could occur would be to revise the introductory objectives of the CRP as follows:

> ...to assist owners and operators of highly erodible lands, other fragile lands (including land with associated ground or surface water that may be vulnerable to contamination), and wetlands in conserving and improving the soil and water resources AND WILDLIFE HABITAT of the farms or ranches of such owners and operators' (from FACTA Chapter 1, section 1230, p. 229, of Title 14 [Cohen 1991], my revision in capitals).

Only if the principal objectives of the CRP are revised in this way will the biologists' recommendations gain an effective context. It does not make much sense to complain about how badly a hammer works as a screwdriver; the CRP was meant to conserve soil and water, not to develop wildlife habitat.

Little reason exists for not making wildlife habitat enhancement a principal objective of the CRP. Enough soil and water conservation practices are compatible with this objective that the options of the ASCS and farmers would not be unduly limited. The potential to provide a relatively inexpensive contribution to protecting endangered species or providing habitat for species with declining populations is a valuable incentive for adoption of this new objective.

The first CRP contracts, involving about 800,000 ha, will expire in fall 1995. In 1996 and 1997, contracts involving 8.9 million ha will expire. The debate over the renewal of these contracts is growing louder as final negotiations for the 1995 farm bill approach. Many CRP contract holders favor the idea of contract extension (Cook 1994); however, simple contract extension may not be a good idea. Payments would be wasted on those farmers who already plan to maintain existing CRP conservation practices, regardless of government support. Critics are also concerned that simple contract extension would fund the continued retirement of some lands under little risk of soil erosion or of lower value to wildlife (Cook 1994). Although CRP bid assessment procedures were changed after 1990 to consider environmental benefits relative to enrollment costs, wildlife habitat was not explicitly considered in the revised procedures. In fact, new guidelines may direct new and renewed CRP contracts away from the wind erosion problems in the Great Plains, where CRP grasslands have been of great benefit to declining bird populations, toward water quality problems in the Great Lakes states, the Northeast, and the Southeast, where wildlife benefits from increased grassland area may be less dramatic (Heimlich and Osborn 1993). To be of value to declining wildlife populations, land retirement programs should be large scale and long term (Noss and Cooperider 1994), address regionally variable limiting habitat factors, and fit into the agro-ecological context of the farming area. Explicit wildlife conservation objectives would provide additional, useful criteria refining the process for selecting the most environmentally important lands to enroll in the CRP.

If Congress does not cut the whole program, but is unwilling to extend the program at its present scale, then priority should be given to those farmers whose bids for CRP rental payments involve lands with the highest value to wildlife.

Collaboration Between Natural Resource Agencies

Interagency communication has been a weak link in the organization and effectiveness of U.S. land management agencies (Sampson 1981; Nation Research Council 1989). As mentioned earlier, insufficient state fish and wildlife agency input into ASCS decision-making processes has been a key problem in expanding wildlife benefits of the

CRP. Protecting and enhancing native flora and fauna are part of the mission of the Fish and Wildlife Service but not a purpose of the Department of Agriculture. Therefore, policies that may enhance the wildlife benefits of federal agriculture programs should mandate the collaboration of the U.S. Department of Agriculture and the Fish and Wildlife Service, providing the authority for interagency cooperation.

Researchers studying the relation between wildlife abundance and the CRP in Minnesota determined that it would cost a wildlife agency $200 million a year to establish the wildlife area of 648,000 ha provided by the CRP in Minnesota (Kimmel et al. 1992). Because part of the mission of the Fish and Wildlife Service would be accomplished through such an expanded CRP, the Fish and Wildlife Service and state wildlife agencies should bear some of the expense for establishment of wildlife habitat and for habitat maintenance. In several states, fish and wildlife agencies have provided money for establishing specific wildlife-enhancing conservation practices on CRP lands (Kimmel et al. 1992; Gordon East, personal communication).

The Acreage Reduction Program

The Acreage Reduction Program (ARP) has involved 7.6 to 21 million ha each year over the past 10 years (Agricultural Stabilization and Conservation Service, personal communication). Management of these lands under annual contract has not changed substantially since the inception of annual land retirement programs in the 1930's. Up to 60% of annual set-aside lands are in summer fallow or are left unseeded (Jahn and Schenck 1990). Weed control and cover destruction requirements present additional threats to wildlife using this land for nesting or cover. Destruction of cover crops or volunteer vegetation is usually required by local ASCS offices halfway through the bird nesting and brooding season (Berner 1988). Acreage Reduction Program regulations in the 1990 farm bill require that only 50% of the area taken out of feed grain production be planted to a cover crop and that lands devoted to the cover crop cannot exceed 5% of the base-acreage established for that crop. This minimal requirement does not even apply in arid areas (Title IV, Section 105B, FACTA, Cohen 1991).

The ARP should be modified to support multiyear set asides of 2 to 4 years. This modification would encourage farmers to develop more effective conservation plans that would allow the establishment of perennial cover crops that would provide wildlife habitat, increase soil fertility, reduce soil erosion, and decrease agricultural chemical leaching or runoff, as well as accomplish the reduction of commodity crop surpluses. These lands could act as an emergency forage reservoir for livestock during bad years, reducing the need for emergency haying on CRP lands. During the 1988 and 1989 droughts, so little vegetation existed on ARP lands that they were unable to supply appreciable emergency forage needs (Jahn and Schenck, 1990). If markets expanded or if a national or international emergency occurred, these lands could easily be returned to row crop production.

Conversion of Farmland to Irreversible Uses

The steady drop in the total area of farmlands, from 470 million ha in 1950 to 390 million ha in 1987, has been detrimental to wildlife habitat (Berner 1988). Part of this 80-million-ha reduction came about as a result of conversion to nonfarm uses (Sampson 1981) in which the land continued to provide habitat. But some of this reduction was a result of irreversible conversion to roads, industrial or residential areas, malls, and other urban uses. Between 1967 and 1975 more than 6.7 million ha of farmland were lost to urban uses, prime farmland accounting for more than 2.6 million ha of these losses (Sampson 1981). Concern about this loss of land has prompted the development of state and federal policy (the Farmland Protection Policy Act 7 U.S.C.A. 4201c, which attempts to prevent federal subsidization of the conversion of prime farmland to non-agricultural uses), but although the conversion of farmland for suburban and urban uses has declined, it has not stopped (Berner 1988).

Although agriculture almost inevitably reduces biological diversity, the loss is minor compared with the disturbance characterized by development for urban uses. In addition, to compensate for reduced availability of farmland, other wildlife habitat may be lost as more cropland is developed from noncropland areas. Efforts at the federal level to reduce the irreversible loss of farmland should be expanded. Perhaps farmers who have steadily received funding from the ASCS for conservation practices on certain lands should have some of that money subject to recapture if those lands are sold for nonagricultural purposes.

Sustainable Agriculture

Sustainable agricultural practices, generally assumed to include increased crop rotation, decreased use of pesticides, and increased use of soil-conserving tillage techniques, are beneficial to fish and wildlife. As part of sustainable farming systems, reduced pesticide use could significantly reduce mortality and increase the viability of some nontarget wildlife populations. No-till, strip cropping, and crop rotations employing cover crops, all sustainable farming practices, have been shown to be beneficial to wildlife (Jahn and Schenck 1991; Robinson 1991). Many biologists studying the decline of farm wildlife species have suggested that the

adoption of sustainable agricultural practices would be a major step in reversing population declines (O'Connor and Boone 1992; Mankin 1993; Rodenhouse et al. 1992). Provisions of the 1990 farm bill supporting the development of more sustainable agricultural practices were funded at very low levels. Until 1992, appropriations for Sustainable Agriculture Research and Extension never exceeded $7 million (Center for Resource Economics 1992). If sustainable agricultural practices are to become the norm, funding for research and education must be increased. Incentive programs could also be developed that directly or indirectly pay farmers to reduce pesticide use and carry out other sustainable farming practices. "Green" incentives are already part of some European farm policies (O'Connor and Shrub 1986; Macdonald and Smith 1990) and should have a place in U.S. farm policy as well.

Agricultural and Conservation Research

Farm bills direct and authorize funding for research in many areas relating to agricultural production, conservation, and marketing. Research sponsored by the Department of Agriculture on biological conservation in the agricultural landscape is extremely limited. Mutual benefits suggest that collaborative research between the Department of Agriculture and the Fish and Wildlife Service should be established in the 1995 farm bill.

Interesting questions abound concerning biological conservation in agricultural areas, beyond those related to habitat development on idled croplands. I discuss below two areas of research in which biological conservation and agriculture are interrelated, the effect of agriculture on the conservation of biological diversity and the importance of biological diversity within sustainable agricultural systems.

Agriculture and Conservation Biology

Although agriculture plays such a key role in the loss of biological diversity, little integration has occurred between the fields of wildlife or conservation biology and agricultural science. Why should conservation biologists develop interdisciplinary relationships with agricultural science? First, many species occur outside of protected natural lands, in areas that are managed for agriculture or forestry. In (the former West) Germany only 35–40% of the 30,000 species cataloged occur in protected areas (Pimental et al. 1992). Second, properly planned agricultural activities can reduce edge effects of protected natural reserve areas (Primack 1993). Third, certain species of conservation concern are adapted to survive in particular agricultural landscapes (Western 1989). And fourth, agricultural landscapes may provide refugia for rare or endangered species (Western 1989).

Soule and Kohm (1989) called for an analysis of measures that could be taken to minimize the amount of land cleared for cultivation. They also suggested a series of interdisciplinary research projects and policy initiatives compiling evidence "that a landscape approach to agricultural intensification within a matrix or network of semi-natural habitats can maintain economically stable and sustainable agricultural systems."

Although these issues are central to conservation biology, in reality they are often peripheral to the most pressing realities of agricultural production. However, there are important areas for research related to the value of biological diversity within sustainable agricultural production systems.

Sustainable Agriculture and Biological Diversity

The function of sustainable, reduced-environmental-impact agriculture may be dependent on biological diversity (Altieri 1990). In the simplified biological systems characteristic of high input agriculture, the capacity for self-regulation inherent in natural communities is removed. Agricultural ecosystems lacking these basic regulatory functions are unable to maintain their own soil fertility, pest regulation, disease control, and so on (Carroll et al. 1990). However, research in a few agricultural systems has shown that these regulatory functions may be reestablished by improving community homeostasis through increasing plant and arthropod diversity (Altieri 1990; Thomas et al. 1992). Little is known about many of the functions of arthropods and microorganisms in the agro-ecosystem, particularly in the soil. Soil is one of the most complicated habitat systems. Data are limited on the effects of farming practices on soil organisms in relation to the ability of the soil to carry out the functions that all terrestrial organisms depend on, such as nutrient availability and uptake, soil aeration and drainage, and germination (Stork and Eggleton 1992; Tucker 1992).

The genetic diversity contained in early crop varieties and wild crop relatives is essential to plant breeders. This genetic diversity is necessary for maintaining and developing high-yielding strains of crops resistant to the environmental stresses imposed in various agricultural landscapes (Altieri 1990; Gilpin et al.1992; Cleveland et al. 1994). Research on conservation methods is essential to conserve this store of genetic material. Research also needs to be conducted on biological diversity as an untapped source for useful crop and livestock species that may be fundamental to sustainable agriculture management (Wilson 1992).

Conclusions

Agriculture is a major factor in the loss of biological diversity and abundance. Mortality resulting from agricultural practices is significant, but population declines attributed to habitat loss or degradation threaten the viability of

wildlife inhabiting the agricultural landscape. Responses to this problem include the development of new agricultural goals, institutions, and policies that incorporate or promote the conservation of biological diversity.

According to the *1990 Fact Book of Agriculture* (U.S. Department of Agriculture 1990), 2.1 million U.S. farmers manage about 400 million ha of our 937-million-ha land base. Thus, in addition to making a living off the land, every U.S. farmer is responsible for managing an average of 190 ha of plantlife, soil, water, and wildlife resources. National policy has affected many of the choices that farmers make in the management of these resources. Federal systems made up of the land grant universities, Cooperative Extension Service, Soil Conservation Service, Agricultural Stabilization and Conservation Service, Department of Agriculture research facilities, agricultural marketing divisions, and federal commodity control programs have all influenced the land-use practices of farmers. The current status of many species indicates that part of this century's legacy of U.S. agricultural goals, institutions, and policies is a dramatic reduction in species abundance and diversity (Dahlberg 1992).

Agricultural conservation policy in the United States has always come as an attachment to programs that control agricultural commodity prices and surplus. But agricultural commodity programs themselves affect environmental quality by influencing farmers' decisions on land-use and management practices. These programs indirectly influence wildlife habitat quality on millions of hectares of farmland (Jahn and Schenck 1990). The potential for improving wildlife habitat through conservation policy has clearly been compromised, when under the guise of conservation, the primary function of the policy has been to control cropland area and subsidize farmers' incomes. Agricultural conservation policy should therefore be uncoupled from agricultural commodity programs. Changing the basis of federal payments to farmers, from base-acreage and historical yield to criteria of stewardship, would result in tremendous benefits to wildlife (Berner 1988; Jahn and Schenck 1991; Berner 1994.

The reduction of environmental problems related to agriculture, such as soil erosion and water pollution, is in many ways complementary to the conservation of species abundance and diversity in agricultural areas. Efforts to control soil erosion or water pollution do not, however, dependably result in enhanced wildlife habitat. The objective of conserving and developing wildlife habitat in the farm landscape must be purposefully incorporated into the more traditional objectives of agricultural conservation policy. This will not only benefit the wildlife of the Prairie and Great Plains states but also could have positive benefits for wildlife nationwide.

At present, humans appropriate about 40% of global terrestrial biological productivity (Vitousek 1992), and that percentage grows with each prairie plowed for cropland, with each wetland drained, with each woodland removed, and with each field verge or headland sprayed with pesticide. Many species that we share this land with will not survive if this percentage grows or even if it remains at its present level. If we do not expand our efforts to reduce the damaging effects of current agricultural practices and policies, the number of species threatened or lost will steadily increase.

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U.S. Department of the Interior
National Biological Service

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